Labs

Generally

Let me summarize

Uni.

Abstract	Because the abstract is a summary, the tenses will reflect those used in the original sections of the report.
Introduction 1	The present simple is used to state the aim and permanent states. The past simple is used to refer to previous experiments.
2 Materials and Methods 3 Methodology	The past simple is mainly used for experimental procedure because the experiment happened in the past and is finished. However, the present simple may be used to explain a figure, equation or model, or to explain the permanent qualities of a material being tested.
4 Results data collected	The present simple is used to explain what a table shows, the past simple to state what the findings were.
Discussion 5	Modal verbs, such as 'may', 'might' and 'should', are often used and these do not show tense.
Conclusion 6	The present perfect may be used to state "This report has shown...". The past simple is used to state what was done or found. Modal verbs might be used to suggest further study or add caution. Modal verbs do not show tense.

Summary

intro → barang² → pasang → measure → measurement → bincang → what d you know?

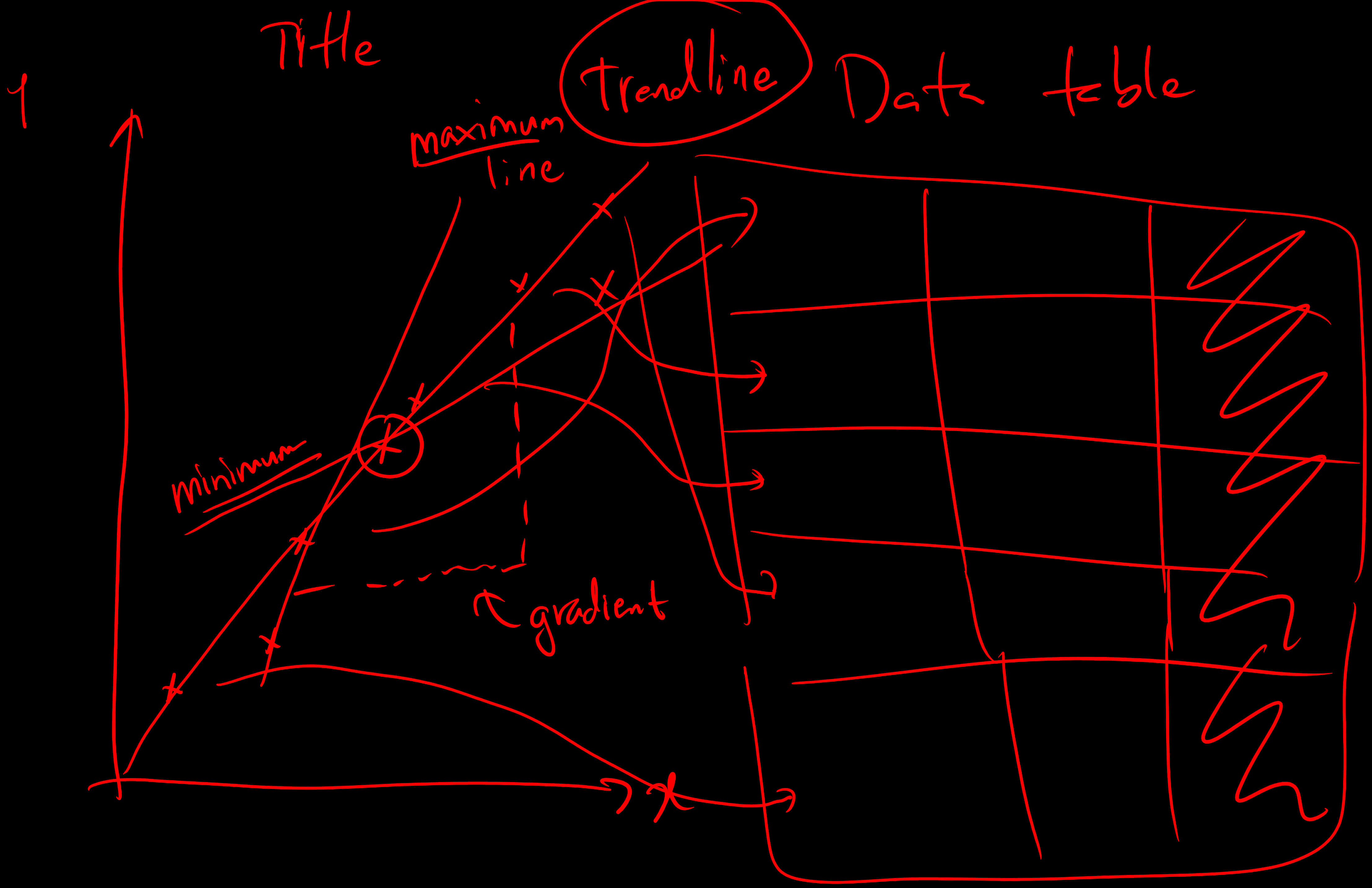
1 Prelim work	
Objective	
Lit rev State 1 related theory	
List all apparatus (with range and sensitivity)	
Method ~~Procedure in passive form~~	

2 Table	
Data with units and consistent decimal points	
All uncertainties with consistent decimal points	
Centroid calculated	
[redacted]	

3 Graph	
Suitable size and scale (80% of the graph paper)	
All points plotted correctly	
Centroid plotted with correct symbol (⊗)	
Title and Axis Label	
Line of max and minimum gradient, best Fit Line and gradient triangle drawn clearly	

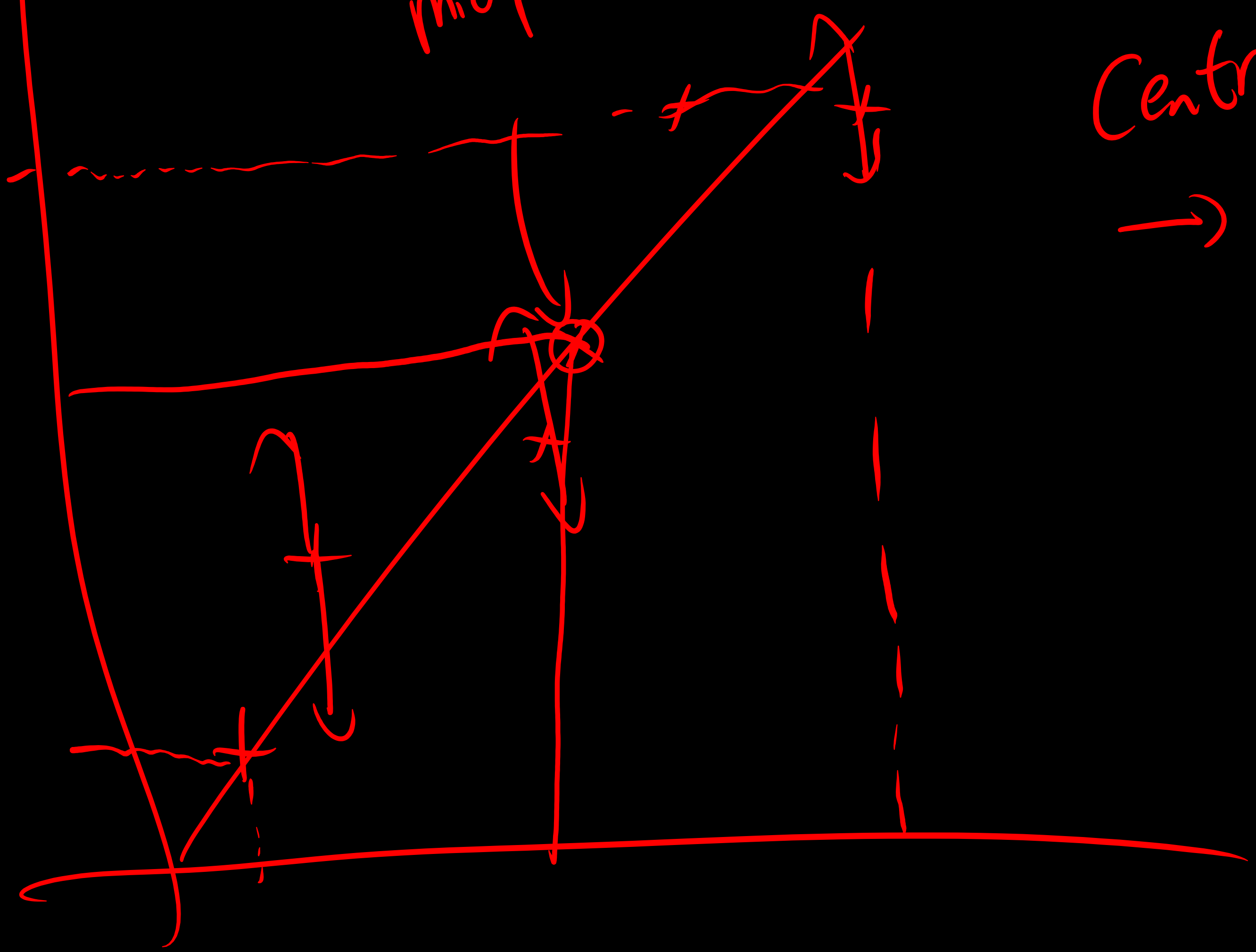
4 Analysis	
m Δm Gradient and gradient uncertainty	
theo value Objective value and uncertainty	
Percentage error calculated Aim < 10%	

5 Discussion	
Give 1 comment about experimental data	
Give 1 point of error (and its approximated deviation) and precaution	
Conclusion	



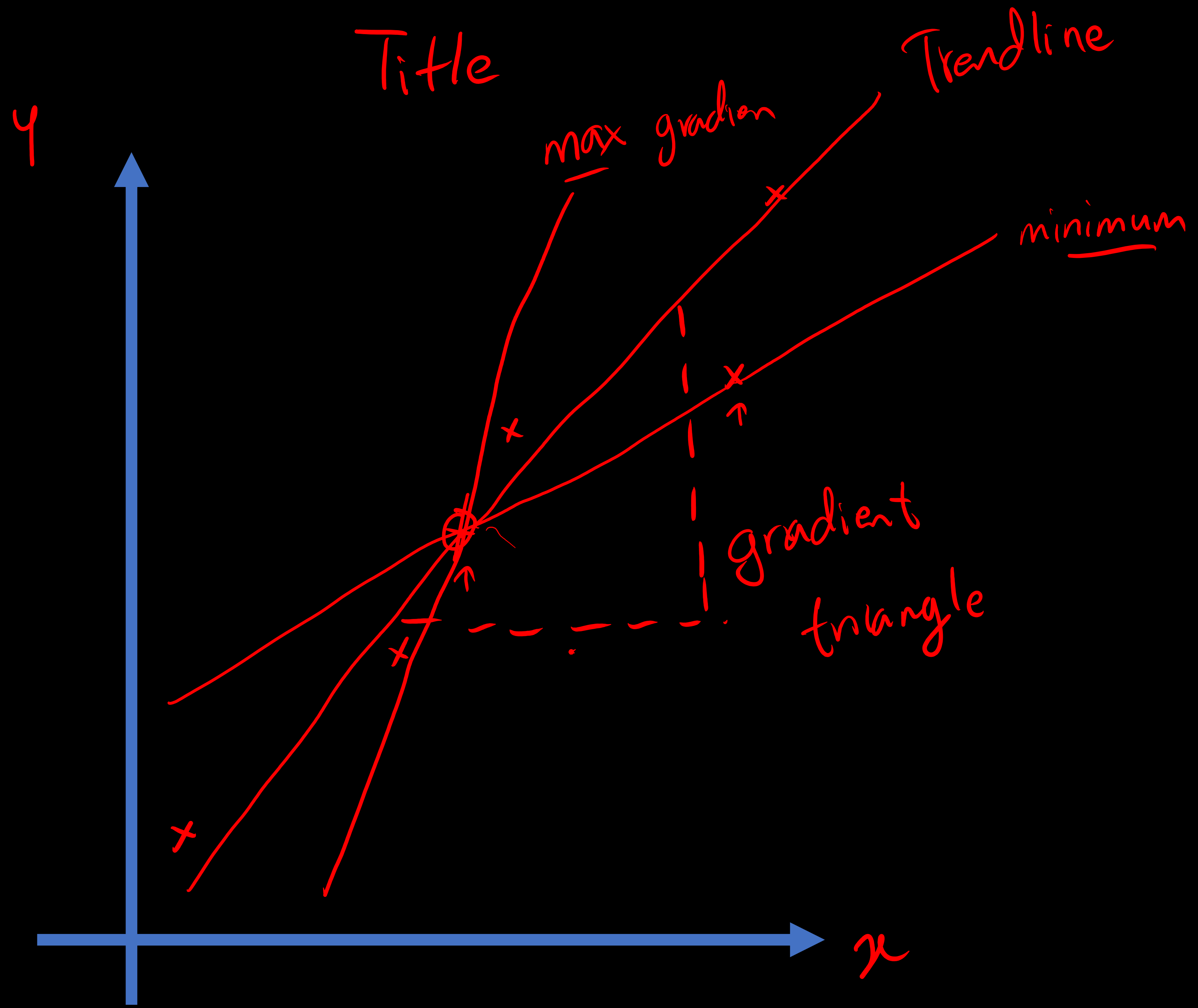
Title
Y
Trendline
Data table
maximum line
minimum
gradient

midpoint (centroid)

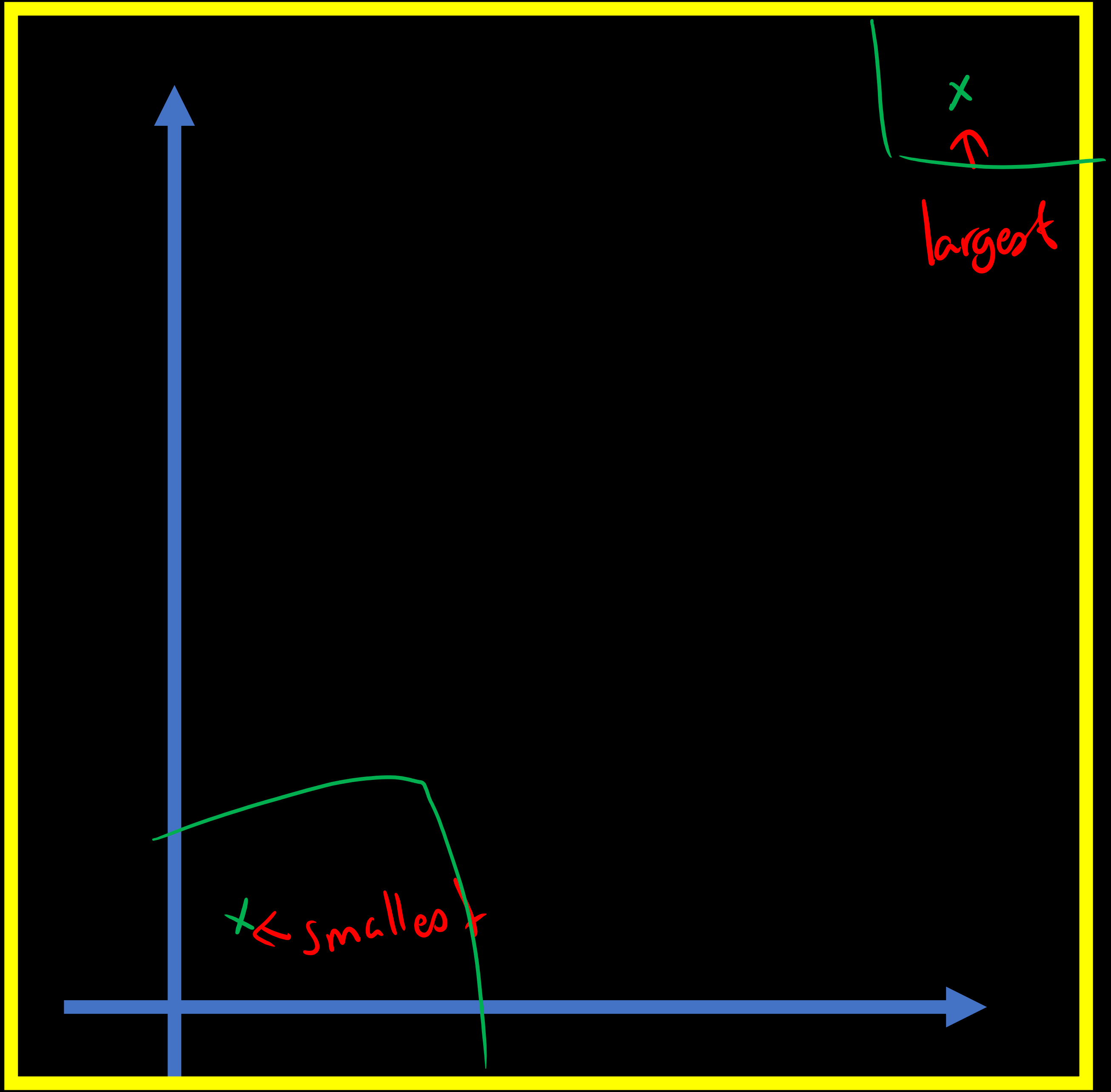


Centroid

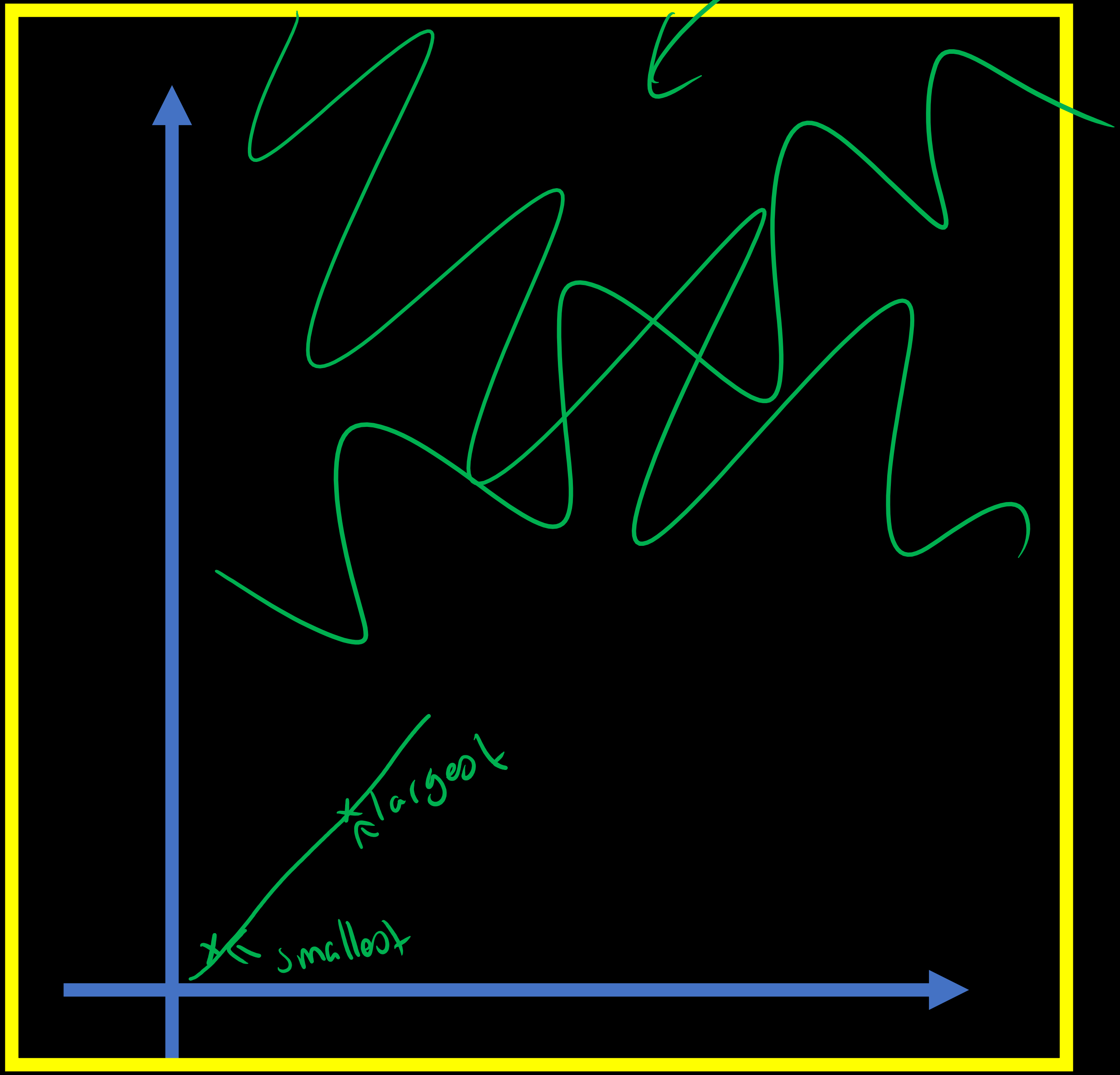
→ minimize uncertainty.


Title
Trendline
y
max gradien
minimum
gradient triangle
x

Scales



wasting X good for environment

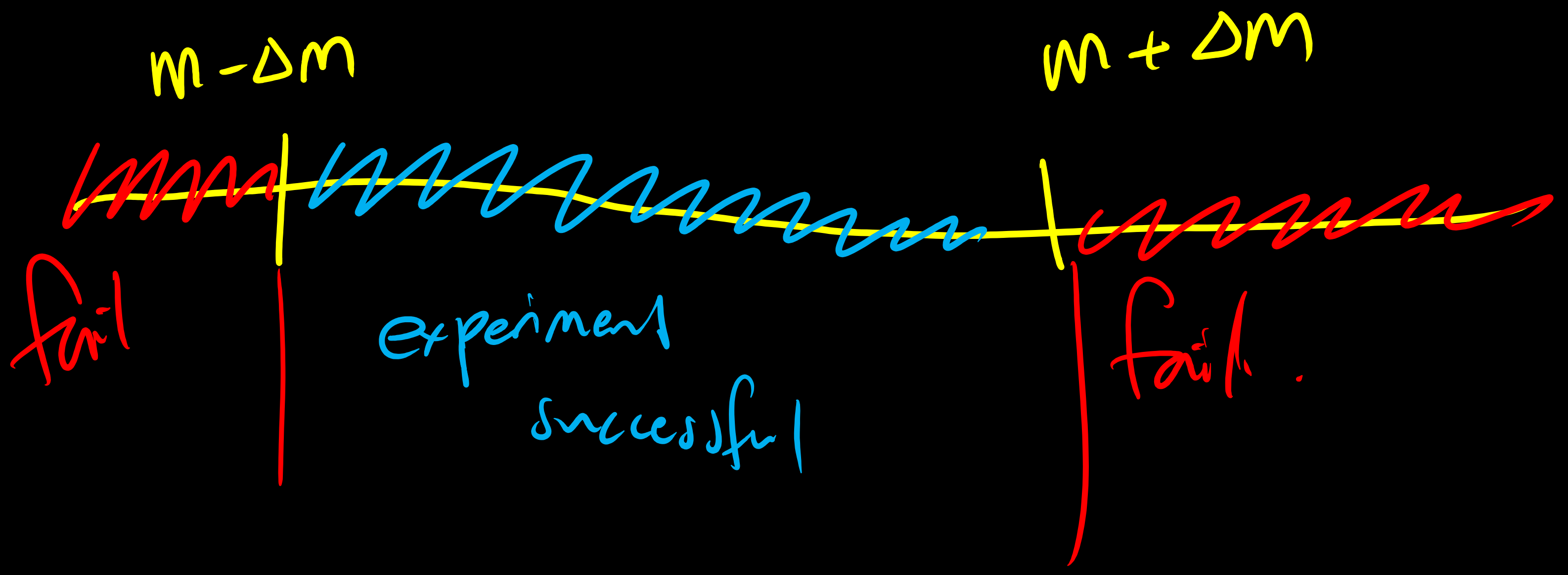


m = gradient

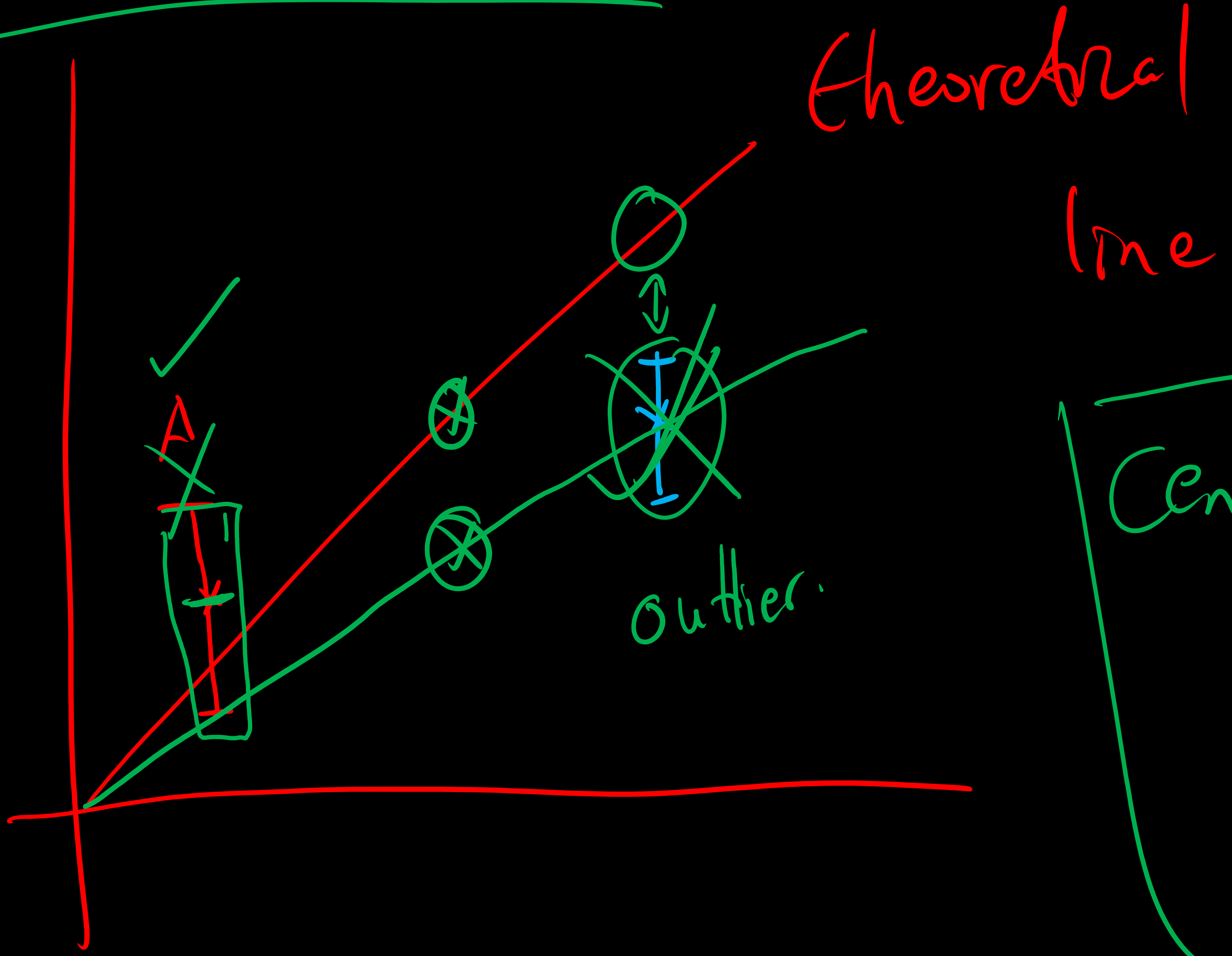
Δm = uncertainty of gradient

m_{theo} = theoretical value

$$m - \Delta m < m_{theo.} < m + \Delta m$$ ✓



Centroid => centre

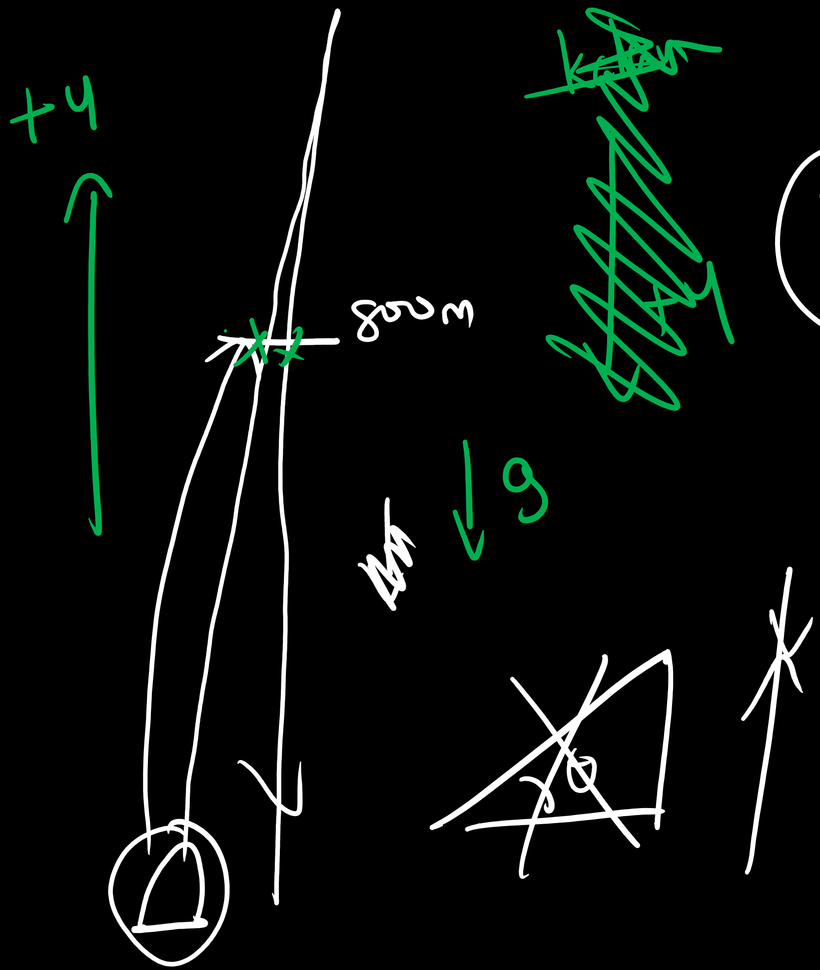


Centroid determines your handdrawn graph

Projectile Motion

Projectile Motion Problems 2

A bullet is fired vertically upwards from the ground with an initial speed of 600 $m\ s^{-1}$. Calculate the time interval, Δt for the bullet to be 800 m above ground

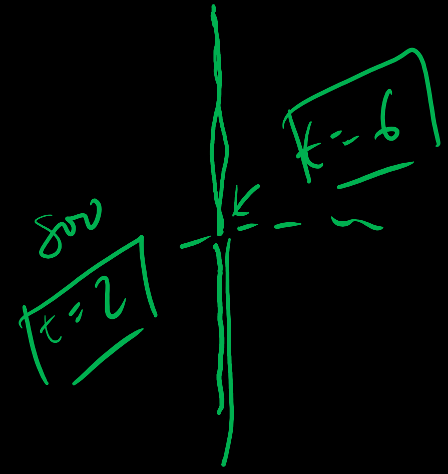


$$V_y = U_y + a_y t \quad \Big| \quad U_y = 600\ ms^{-1}$$

$$S_y = u_y t + \frac{1}{2} a_y t^2$$

$$\underbrace{+800 = 600(t) + \frac{1}{2}(-g)t^2}_{\text{quad eqn.}}$$

$$t \rightarrow \boxed{2\ \text{value}}$$



Projectile Motion Problems 3

An archer standing on a cliff 48 m high shoots an arrow at an angle of 30^o above the horizontal with a speed of 80 ms^{-1}. Calculate the duration the arrow is in the air ~~and the horizontal range~~ angle of ~~the arrow~~.

Joseph ✓

$$U = 80\, ms^{-1} \Rightarrow U_y = U \sin\theta = 80 \sin 30^\circ = 40$$

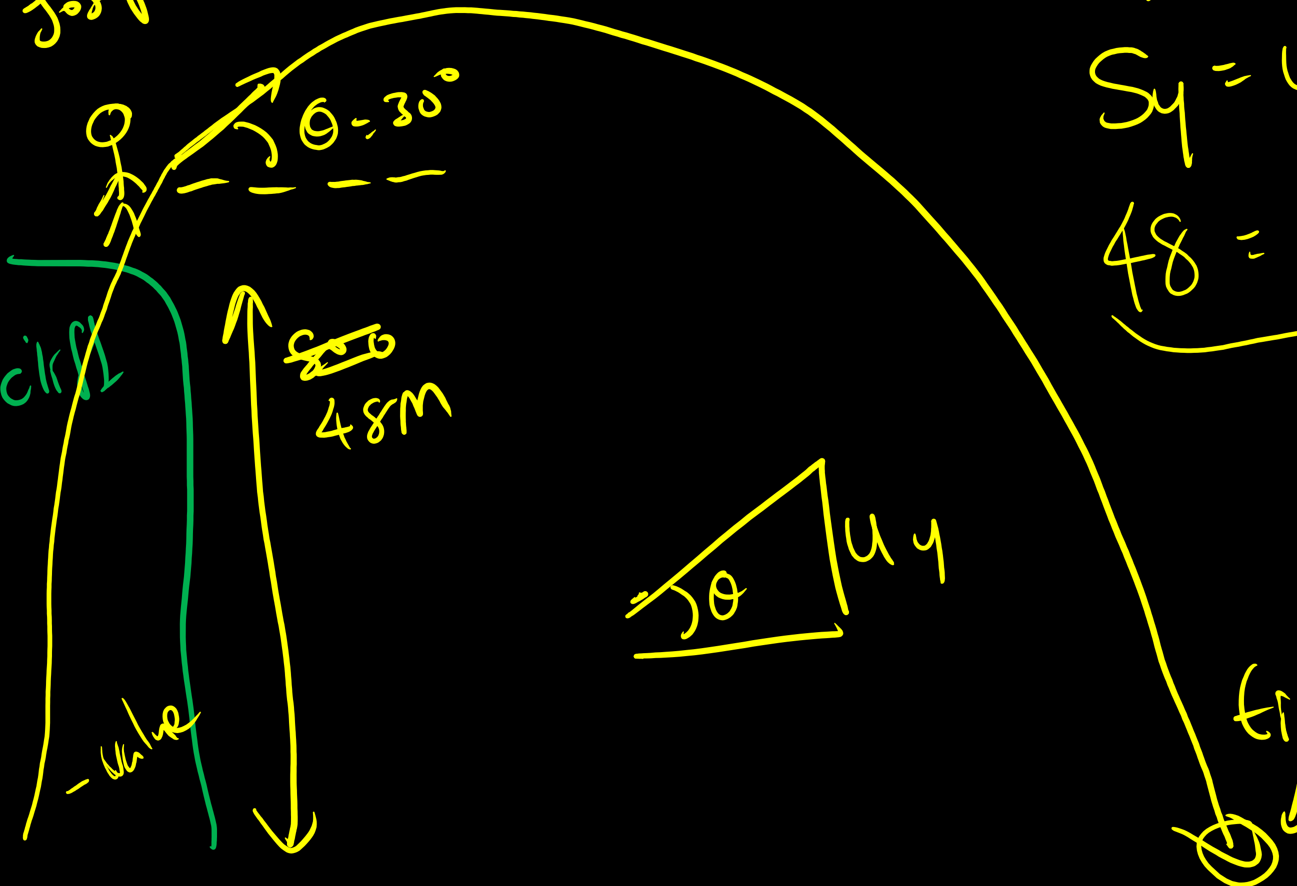
$$U_x = U \cos\theta = 80 \cos 30 = 69.28$$

$$S_y = U_y t + \frac{1}{2} a_y t^2$$

$$\underbrace{48 = 40(t) + \frac{1}{2}(-g)t^2}$$

1 ⇒ − value

2 ⇒ + value

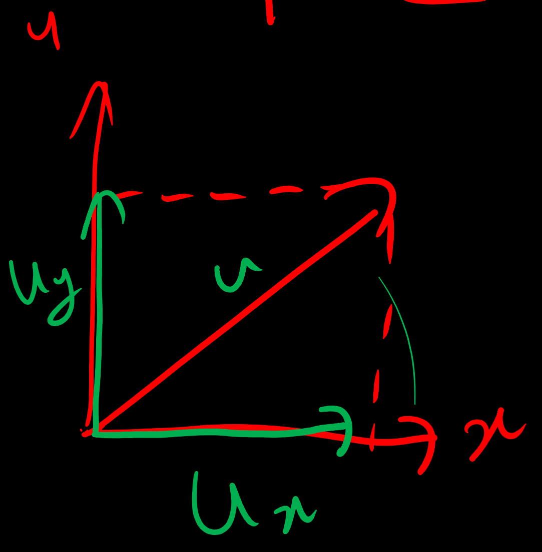


time ↓ + value

Projectile Motion Problems 3

An archer standing on a cliff 48 m high shoots an arrow at an angle of 30^o above the horizontal with a speed of 80 ms^{-1}. Calculate the duration the arrow is in the air and the horizontal riltge of the arrow.

Why $\underline{u_x}$ & $\underline{u_y}$



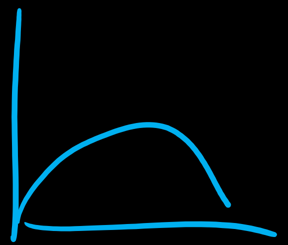
g only acts in the y-direction

$V_x = u_x$

$V_y = u_y \boxed{-gt}$

Projectile Motion Problems 4

A ball is thrown at a 35^o angle above the horizontal with a speed of $45ms^{-1}$. Calculate its velocity 3 seconds after it is thrown.



$u = 45 ms^{-1}$

$u_x = u\cos\theta = 36.86$

$u_y = u\sin\theta = 25.81$

$V_x = u_x = 36.86$

$V_y = u_y + a_y t$

$a_y = -g$

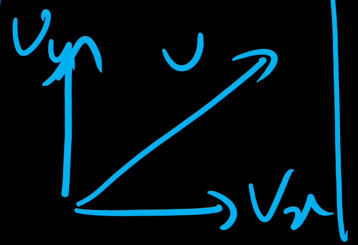
$V_y = u_y - gt$

$V_y = 25.81 - 9.81(3)$

$= -3.62\ ms^{-1}$

$V_x ✓ \; ; \; V_y ✓$

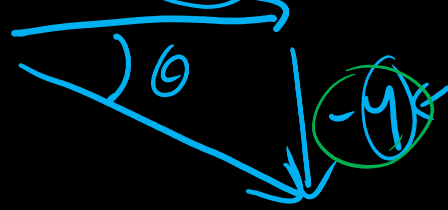
Pythagoras



$V = \sqrt{(V_x)^2 + (V_y)^2}$

$= \left[(36.86)^2 + (-3.62)^2\right]^{1/2}$

$V = 37.037\ ms^{-1}$



$\tan\theta = \dfrac{3.62}{36.86} \Rightarrow \theta \approx 5.61$

Projectile Motion Problems 4

A ball is thrown at a 35^o angle above the horizontal with a speed of $45ms^{-1}$. Calculate its velocity 3 seconds after it is thrown.

$V \approx 37.037$ below the horizontal. at an angle $5.61°$

$y < 0$

Friday Quiz

3 Soalan

- Kinematics 1D
- Projectile motion
- maths.

Siapa dpt full mark boleh skip next Quiz

THANK YOU!

6/8/2021 Session

Chapter 3

Quiz Chapter 1 & 2

Definitions

$\boxed{\vec{p}} = m\vec{v}$ } momentum.

Impulse, $\vec{J} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i$

$\boxed{\vec{J} = m\vec{v}_f - m\vec{v}_i}$

$= \vec{v}(m_f - m_i)$

Law

Conservation of momentum

$\sum p_f = \sum p_i$

Equations

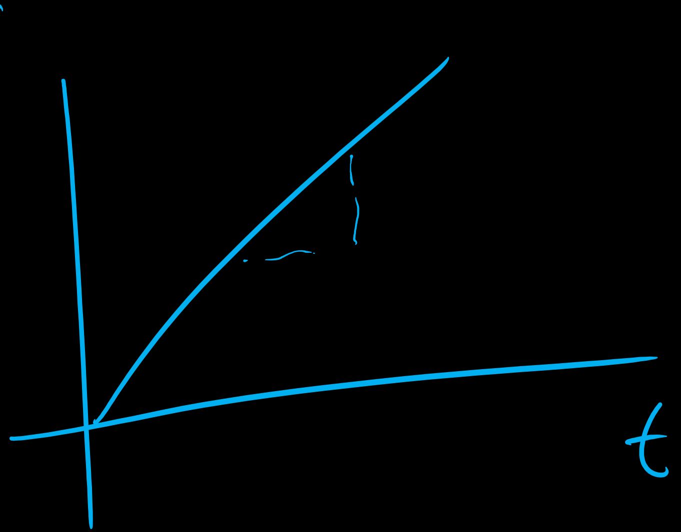
$\vec{p} = m\vec{v}$

$\vec{J} = \Delta\vec{p}$

Chapter 4

$\vec{F} = \frac{d\vec{p}}{dt} = \frac{\Delta\vec{p}}{\Delta t} \to J$

$\vec{J} = \vec{F}\Delta t$

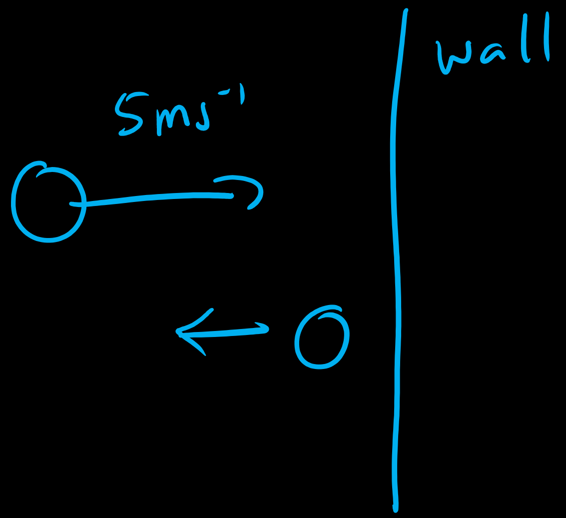


1. A 500 g squash ball is travelling towards a wall on its right with a speed of $5ms^{-1}$. It then hits the wall and bounce back with the same speed in 0.3 s.

   a) Find the momentum of the squash ball

   b) Find the impulse of the ball

   c) Find the impulsive force on the ball



$t = 0.3s$

$\vec{P} = m\vec{v}$

$\vec{P_i} = m\vec{V_i}$

$= (0.5)(5)$

$= 2.5\ kgms^{-1}$

$= 2.5\ Ns$

$\cancel{\vec{P_i} = (500)(5)}$

$\cancel{= 2500\ g\ ms^{-1}}$

Stick with SI unit

1. A 500 g squash ball is travelling towards a wall on its right with a speed of $5ms^{-1}$. It then hits the wall and bounce back with the same speed in 0.3 s.

   a) Find the momentum of the squash ball

   b) Find the impulse of the ball

   c) Find the impulsive force on the ball

$\vec{P_i} = 2.5\ Ns$

$\vec{P_f} = m\vec{V_f}$

$= (0.5)(-5ms^{-1})$

$= -2.5\ Ns$

$\vec{J} = m(\vec{V_f}) - \vec{V_i})$

$= 2.5 - (-2.5))$

$\vec{J} = 5\ Ns$

$\boxed{\text{Direction matters.}}$

1. A 500 g squash ball is travelling towards a wall on its right with a speed of $5ms^{-1}$. It then hits the wall and bounce back with the same speed in 0.3 s.

   a) Find the momentum of the squash ball

   b) Find the impulse of the ball

   c) Find the impulsive force on the ball

$$F = \frac{J}{\Delta t}$$

$$J = F\boxed{\Delta t}$$

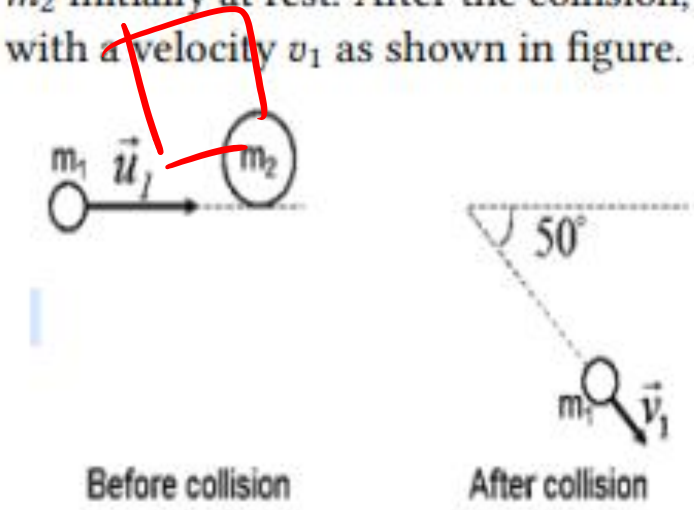
$$F = \frac{J}{\Delta t} = \frac{5\ Ns}{0.3\ s}$$

$$F = 16.67\ N$$

Thank you!

CONSERVATION OF LINEAR MOMENTUM

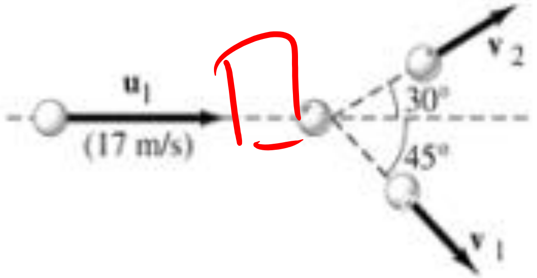
3. A tennis ball of mass m_1 moving with initial velocity u_1 collides with a soccer ball of mass m_2 initially at rest. After the collision, the tennis ball is deflected from its initial direction with a velocity v_1 as shown in figure.



Suppose that m_1 = 250 g, m_2 = 900 g, u_1 = $20ms^{-1}$ and v_1 = $4ms^{-1}$.

Calculate the magnitude and direction of soccer ball after the collision.

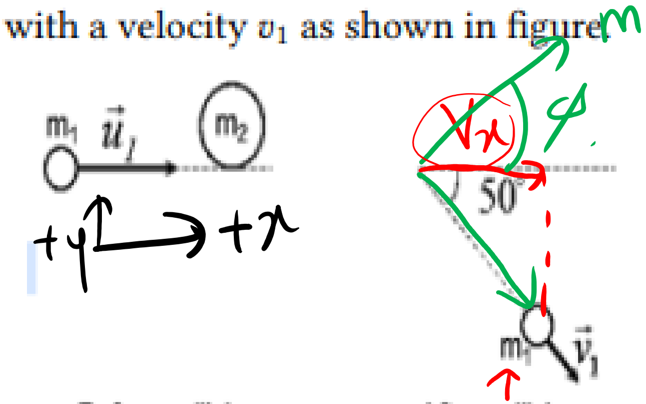
4. A ball moving with a speed of $17ms^{-1}$ strikes an identical ball that is initially at rest.



After the collision, the incoming ball has been deviated by 45^0 from its original direction, and the struck ball moves off at 30^0 from the original direction as shown in figure.

Calculate the speed of each ball after the collision

3. A tennis ball of mass m_1 moving with initial velocity u_1 collides with a soccer ball of mass m_2 initially at rest. After the collision, the tennis ball is deflected from its initial direction with a velocity v_1 as shown in figure.



Before collision After collision

Suppose that m_1 = 250 g, m_2 = 900 g, u_1 = 20ms^{-1} and v_1 = 4ms^{-1}.

Calculate the magnitude and direction of soccer ball after the collision.

$$\sum \vec{P}_{xf} = \sum \vec{P}_{xi}$$

$$\sum \vec{P}_{yf} = \sum \vec{P}_{yi}$$

Initial	Final
$m_1 u_1 + \cancel{m_2 u_2}^{0}$	$m_1 V_1 + m_2 V_2$
$m_1 u_1$	$V_x = V_1 \cos\theta$
	$\theta = 50°$

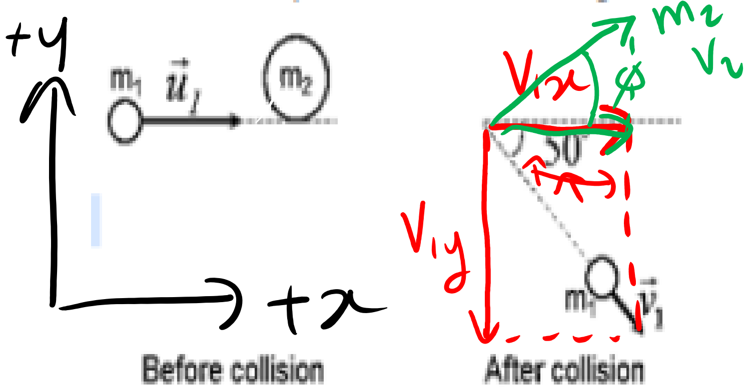
$$V_1 = \sqrt{(V_{x1})^2 + (V_{y1})^2}$$

x-component

$$\sum \vec{P}_{xi} = m_1 u_1$$

$$\sum \vec{P}_{xf} = \boxed{m_1(\underbrace{V_1 \cos\theta}_{V_{x1}})} + m_2 \boxed{\underbrace{V_2 \cos\phi}_{V_{2x}}}$$

3. A tennis ball of mass m_1 moving with initial velocity u_1 collides with a soccer ball of mass m_2 initially at rest. After the collision, the tennis ball is deflected from its initial direction with a velocity v_1 as shown in figure.



Suppose that m_1 = 250 g, m_2 = 900 g, u_1 = $20ms^{-1}$ and v_1 = $4ms^{-1}$.

Calculate the magnitude and direction of soccer ball after the collision.

$V_{1x} = V_1 \cos\theta$; V_{2x} ~~cos~~ $= V_2 \cos\phi$

$\sum P_f = \sum P_i$

2D ↓

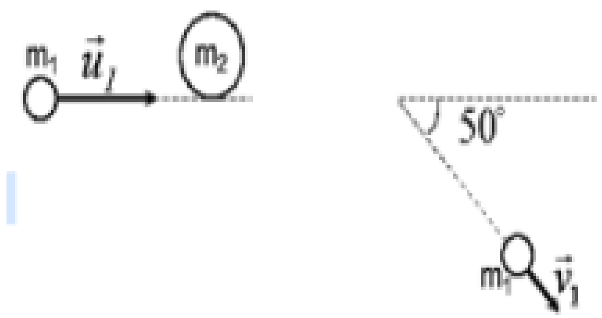
$\sum P_{fx} = \sum P_{ix}$

$\sum P_{fy} = \sum P_{iy}$

	initial	final
x-component	$m_1 u_1 = \sum P_{xi}$ (a)	$m_1 V_1 \cos\theta + m_2 V_2 \cos\phi = \sum P_{xf}$ (b) (1)
y-component	$0 = \sum P_{yi}$	$m_1 V_1 \sin\theta + m_2 V_2 \sin\phi = \sum P_{yf}$

$V_{1y} = V_1 \sin\theta$

3. A tennis ball of mass m_1 moving with initial velocity u_1 collides with a soccer ball of mass m_2 initially at rest. After the collision, the tennis ball is deflected from its initial direction with a velocity v_1 as shown in figure.



Before collision   After collision

Suppose that $m_1 = 250$ g, $m_2 = 900$ g, $u_1 = 20ms^{-1}$and $v_1 = 4ms^{-1}$.

Calculate the magnitude and direction of soccer ball after the collision.

Simultaneous eqn

$$\Delta \sum p_x = 0$$

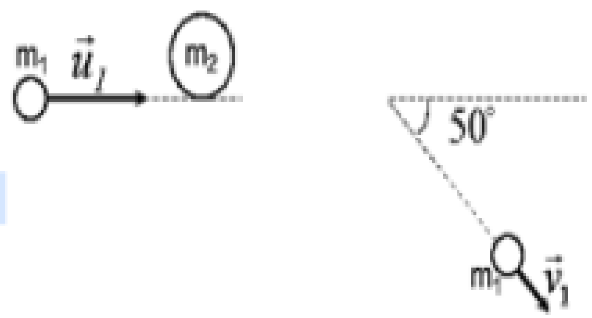
$$\sum p_{xi} = \sum p_{xf}$$

$$m_1 u_1 = m_1 v_1 \cos\theta + m_2 v_2 \cos\phi.$$

$$m_1 (u_1 - v_1 \cos\theta) = m_2 v_2 \cos\phi$$

$$\frac{m_1}{m_2}(u_1 - v_1 \cos\theta) = \boxed{v_2} \cos \boxed{\phi} \quad -(1)$$

3. A tennis ball of mass m_1 moving with initial velocity u_1 collides with a soccer ball of mass m_2 initially at rest. After the collision, the tennis ball is deflected from its initial direction with a velocity v_1 as shown in figure.



Before collision After collision

Suppose that m_1 = 250 g, m_2 = 900 g, u_1 = $20ms^{-1}$and v_1 = $4ms^{-1}$.

Calculate the magnitude and direction of soccer ball after the collision.

$$\Delta \sum P_y = 0$$

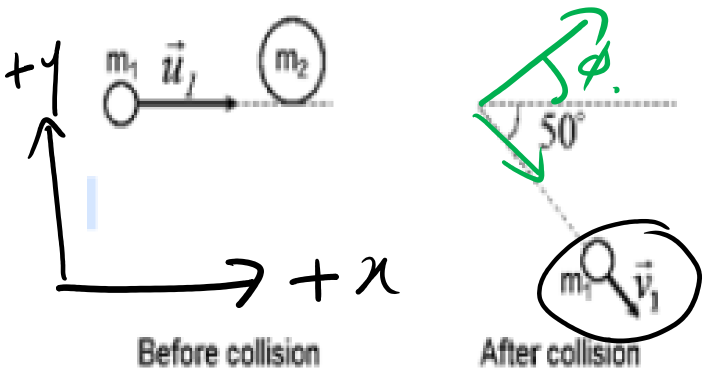
$$\sum P_{yi} = \sum P_{yf}$$

$$0 = m_1 V_1 \sin\theta + m_2 V_2 \sin\phi$$

$$-m_1 V_1 \sin\theta = m_2 V_2 \sin\phi$$

$$-\frac{m_1}{m_2} V_1 \sin\theta = V_2 \sin\phi \quad \text{— ②}$$

3. A tennis ball of mass m_1 moving with initial velocity u_1 collides with a soccer ball of mass m_2 initially at rest. After the collision, the tennis ball is deflected from its initial direction with a velocity v_1 as shown in figure.



Suppose that $m_1 = 250$ g, $m_2 = 900$ g, $u_1 = 20ms^{-1}$ and $v_1 = 4ms^{-1}$.

Calculate the magnitude and direction of soccer ball after the collision.

$$\frac{m_1}{m_2}(u_1 - V_1 \cos\theta) = V_2 \cos\phi \quad — ①$$

$$-\frac{m_1}{m_2} V_1 \sin\theta = V_2 \sin\phi \quad — ②$$

$$0.8512 = V_2 \sin\phi \quad — ①$$

$$4.8413 = V_2 \cos\phi \quad — ②$$

$$\frac{\cancel{V_2} \sin\phi}{\cancel{V_2} \cos\phi} = \frac{0.8512}{4.8413}$$

$$\tan(\phi) = 0.1758$$

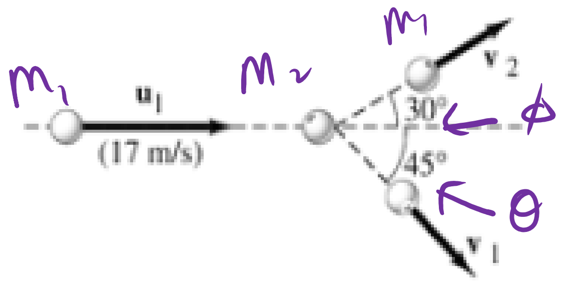
$$\phi = 9.9707^\circ$$

$$V_2 \approx \frac{0.8512}{\sin(9.97)}$$

$$V_2 \approx 4.9165\ ms^{-1}$$

above the x-axis

4. A ball moving with a speed of $17 ms^{-1}$ strikes an identical ball that is initially at rest.



After the collision, the incoming ball has been deviated by 45^0 from its original direction, and the struck ball moves off at 30^0 from the original direction as shown in figure.

Calculate the speed of each ball after the collision

$m_1 = m_2 = m$

$$\Sigma p_{xi} = \Sigma p_{xf}$$

&

$$\Sigma p_{yi} = \Sigma p_{yf}$$

$$\left.\begin{matrix} V_{2x} \\ V_{2y} \end{matrix}\right\} V_2 = \sqrt{V_{2x}^2 + V_{2y}^2}$$

$$\left.\begin{matrix} V_{1x} \\ V_{1y} \end{matrix}\right\} V_1 = \sqrt{V_{1x}^2 + V_{1y}^2}$$

TRY BUAT SENDIRI

12/08/2021 Session

2PM – 4PM

2. A 30 kg block is placed on an inclined plane with an angle of 20^0 with the horizontal as shown in FIGURE 4.8.

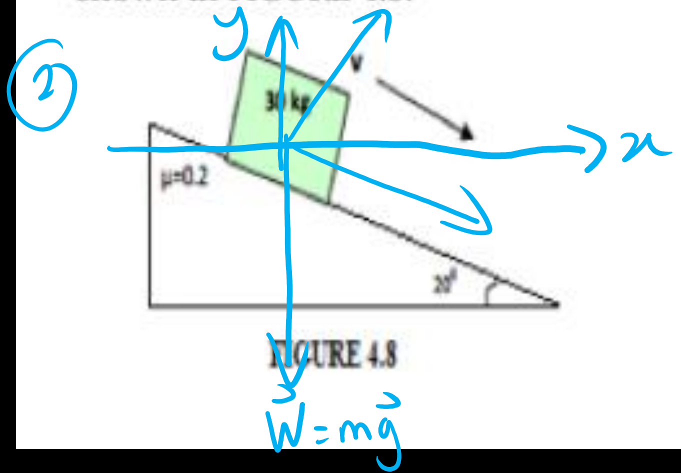


FIGURE 4.8

The coefficient of kinetic friction between the block and the inclined plane is 0.2.

a) Draw a free body diagram to show all the forces acting on the block.

b) Determine the kinetic friction force, f_k acting on the block

more complicated

X

2. A 30 kg block is placed on an inclined plane with an angle of 20^0 with the horizontal as shown in FIGURE 4.8.

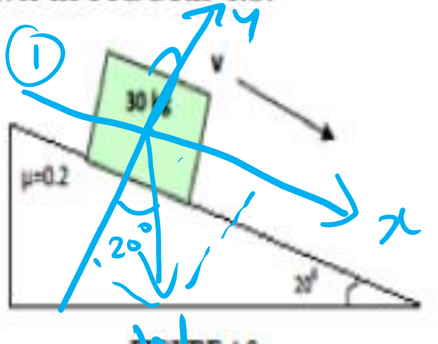


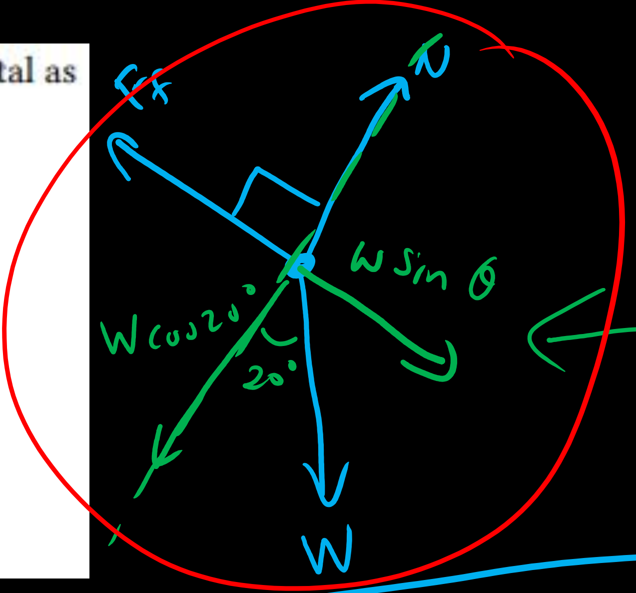
FIGURE 4.8

The coefficient of kinetic friction between the block and the inclined plane is 0.2.

$F_f = \mu N = \mu_k N$

a) Draw a free body diagram to show all the forces acting on the block.

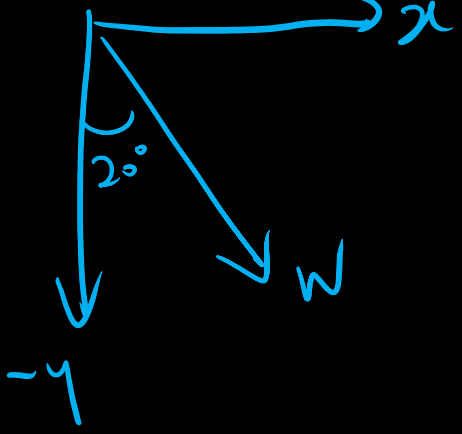
b) Determine the kinetic friction force, f_k acting on the block



N, W, ~~X~~, Fs

$W_x = W \sin 20°$

$W_y = W \cos 20°$



y:

$F_{total} = W \cos 20 - N$

x:

$F_{total} = W \sin 20 - F_f$

b) if $\Delta V = 0$, $a = 0$, $F_{total} = 0$

if $\Delta V \neq 0$, $a \neq 0$, $F_{total} \neq 0$

$f_k = \mu_k N$

$= 0.2(W \cos 20°)$

$= 55.3103\,N$

Jawapan

2. A 30 kg block is placed on an inclined plane with an angle of 20^0 with the horizontal as shown in FIGURE 4.8.

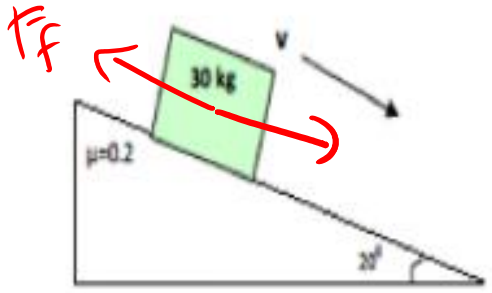


FIGURE 4.8

The coefficient of kinetic friction between the block and the inclined plane is 0.2.

a) Draw a free body diagram to show all the forces acting on the block.

b) Determine the kinetic friction force, f_k acting on the block

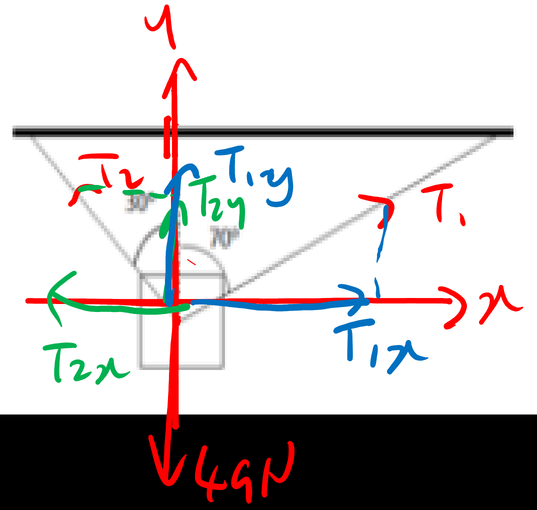
$W \sin\theta = 100.65$

$\cancel{-88.86 + 100.65 = F_x}$

$F_x = 100.65 - 55.31$

$= 45.34 \text{ N}$

2.

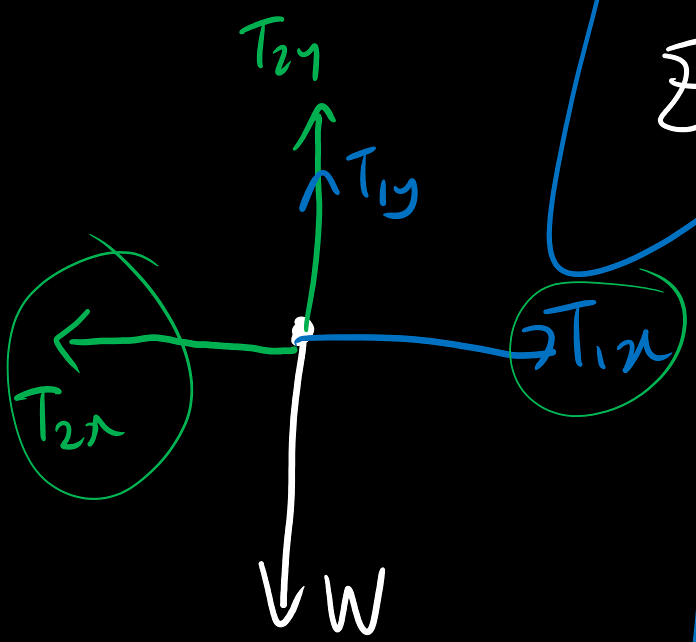


An object of weight W = 49 N is suspended by two strings which are at 30⁰ and 70⁰ to the vertical as shown below.

The object is in equilibrium. Calculate the tension in each string.

$F_{net} = 0$

$\left.\begin{array}{l}\sum F_x = 0 \\ \sum F_y = 0\end{array}\right\}$ separate x & y. if 2D

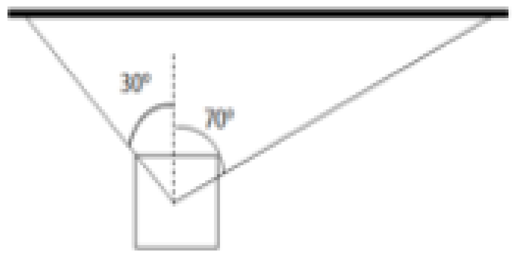


$$\sum F_x = \boxed{0} = T_{2x} - T_{1x} = T_2 \sin 30 - T_1 \sin 70^\circ$$

$$\cancel{\sum F_y = W - T_{2y}} - T_2$$

$$\sum F_y = 0 = W - (T_{2y} + T_{1y})$$

$$W = T_2 \cos 30 + T_1 \cos 70.$$

2. 

An object of weight $\boxed{W = 49\text{ N}}$ is suspended by two strings which are at 30^0 and 70^0 to the vertical as shown below.

The object is in equilibrium. Calculate the tension in each string.

$T_1 = (\qquad)$

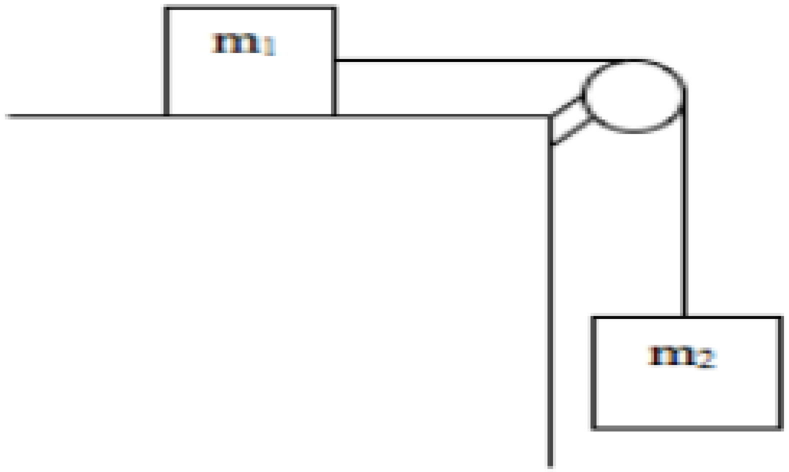
$T_2 = (\qquad)$

$$T_2 \sin 30° = T_1 \sin 70°$$

$$W = T_2 \overset{\cos}{\cancel{\sin}}\ 30 + T_1 \cos 70$$

2 unknowns & 2 equations } simultaneous equation

7. Figure shows a block of mass $m_1 = 6.0kg$ on a smooth horizontal surface, connected by a string through a pulley to another block of mass $m_2 = 3.0kg$.



The system is released from rest

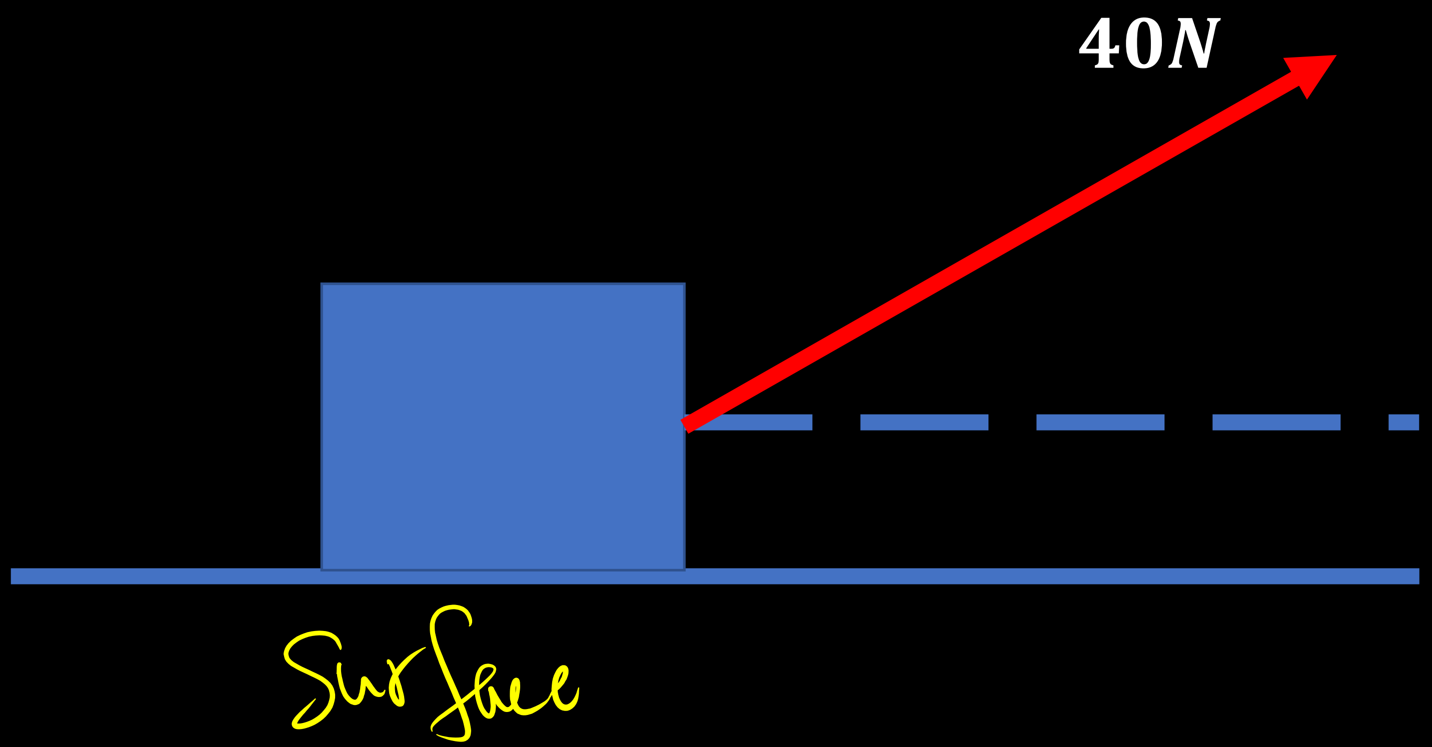
a) Draw the forces acting on the blocks when they are in motion

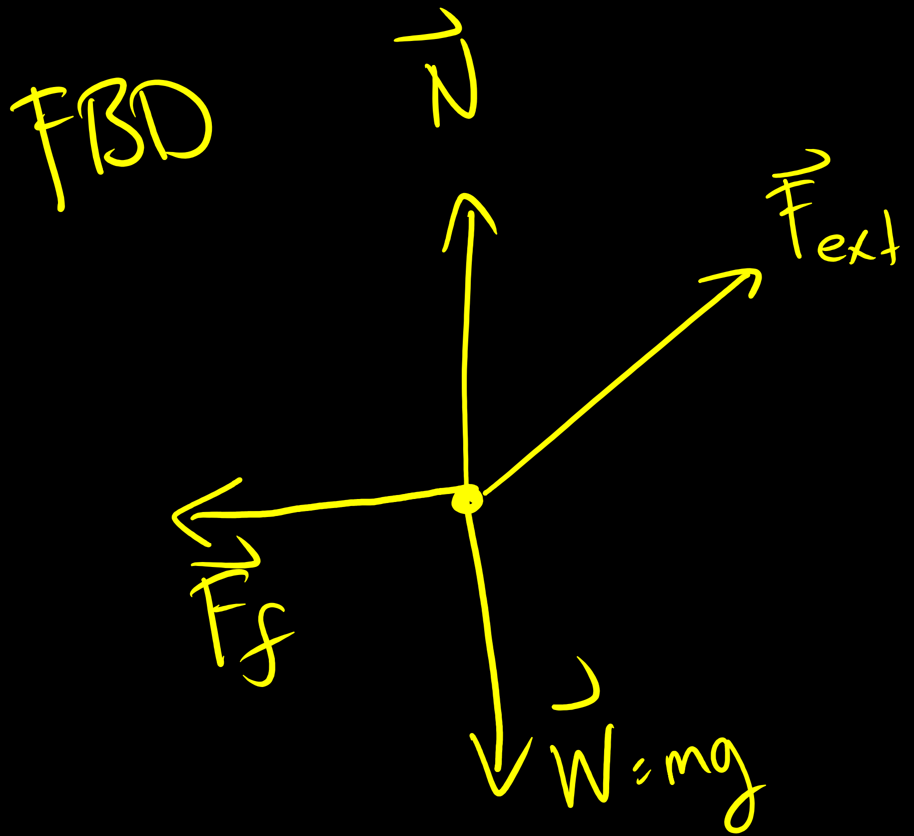
b) Calculate the acceleration of the blocks

c) Calculate the tension in the string

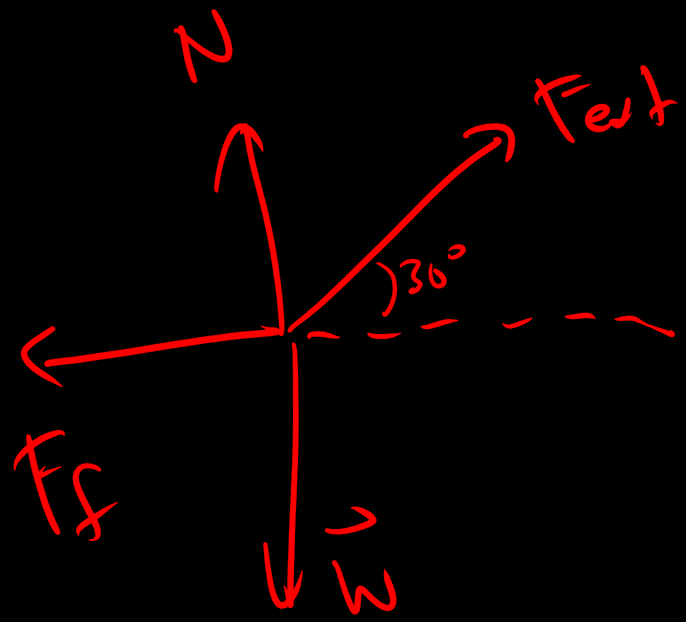
Corrected Version !!!

5. A 10.0 kg box is pulled along a horizontal surface by a force of 40.0 N applied at a angle 30^0 above the horizontal. We assume a coefficient of kinetic friction is 0.3. Calculate the acceleration.





5. A 10.0 kg box is pulled along a horizontal surface by a force of 40.0 N applied at a angle 30^0 above the horizontal. We assume a coefficient of kinetic friction is 0.3. Calculate the acceleration.



$x: \sum F_x = F_{ext} \cos 30 - F_f$

$\sum F_x = 40 \cos 30 - \mu_k N = ma$

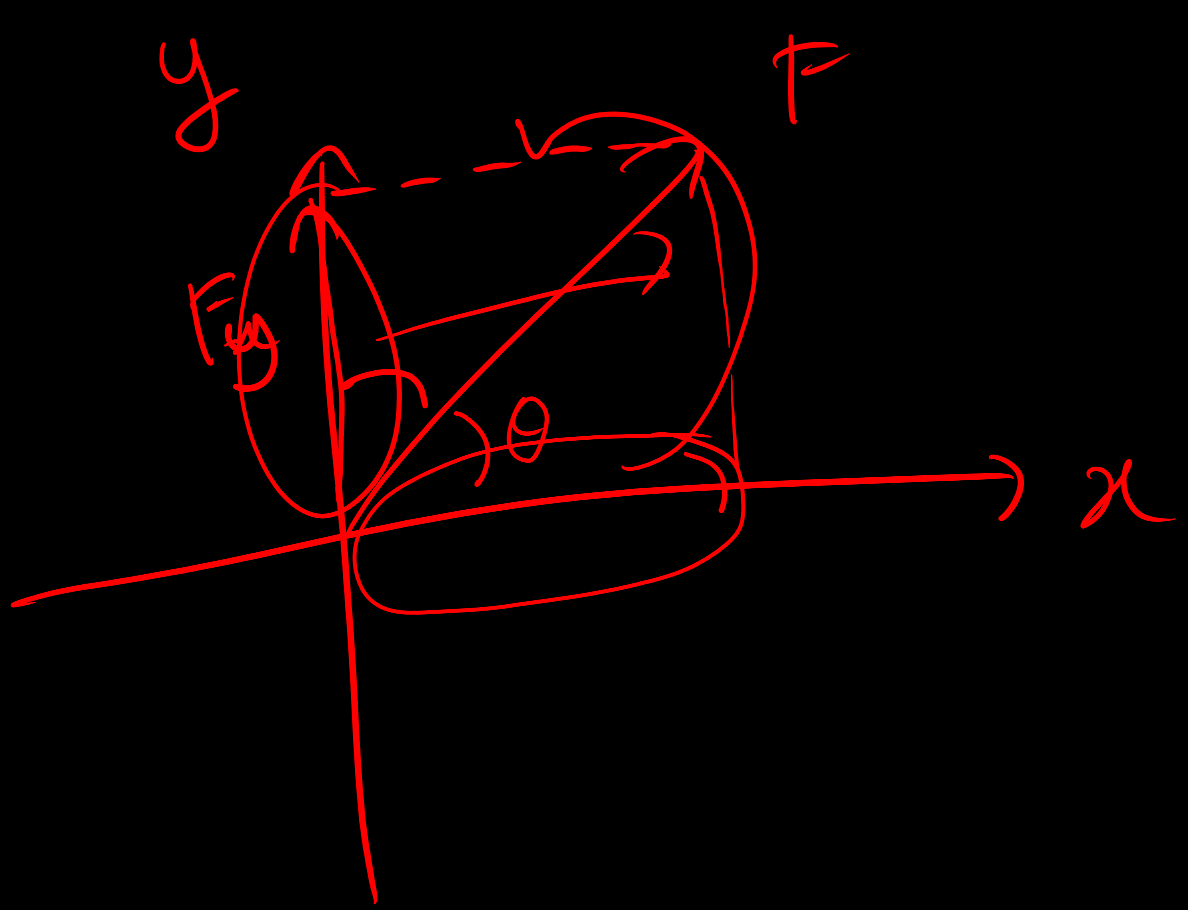
$y: \sum F_y = N + F_{ext} \sin 30 - W = 0$

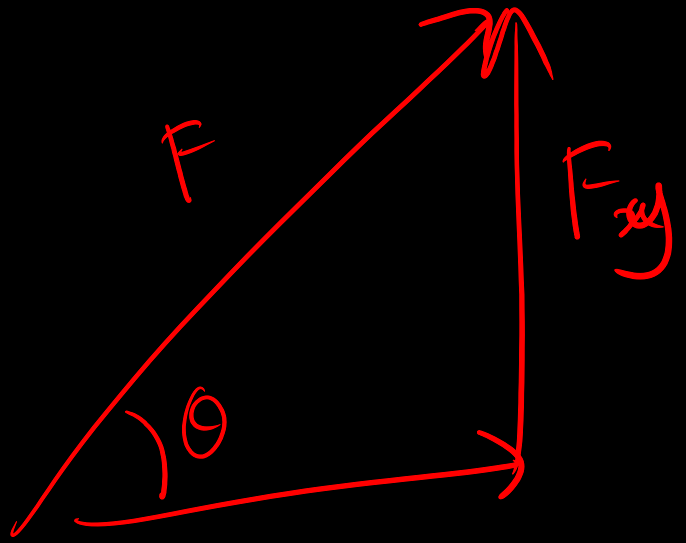
$N = W - 40 \sin 30$

$= 98.1 - 20 = 78.1\,N$

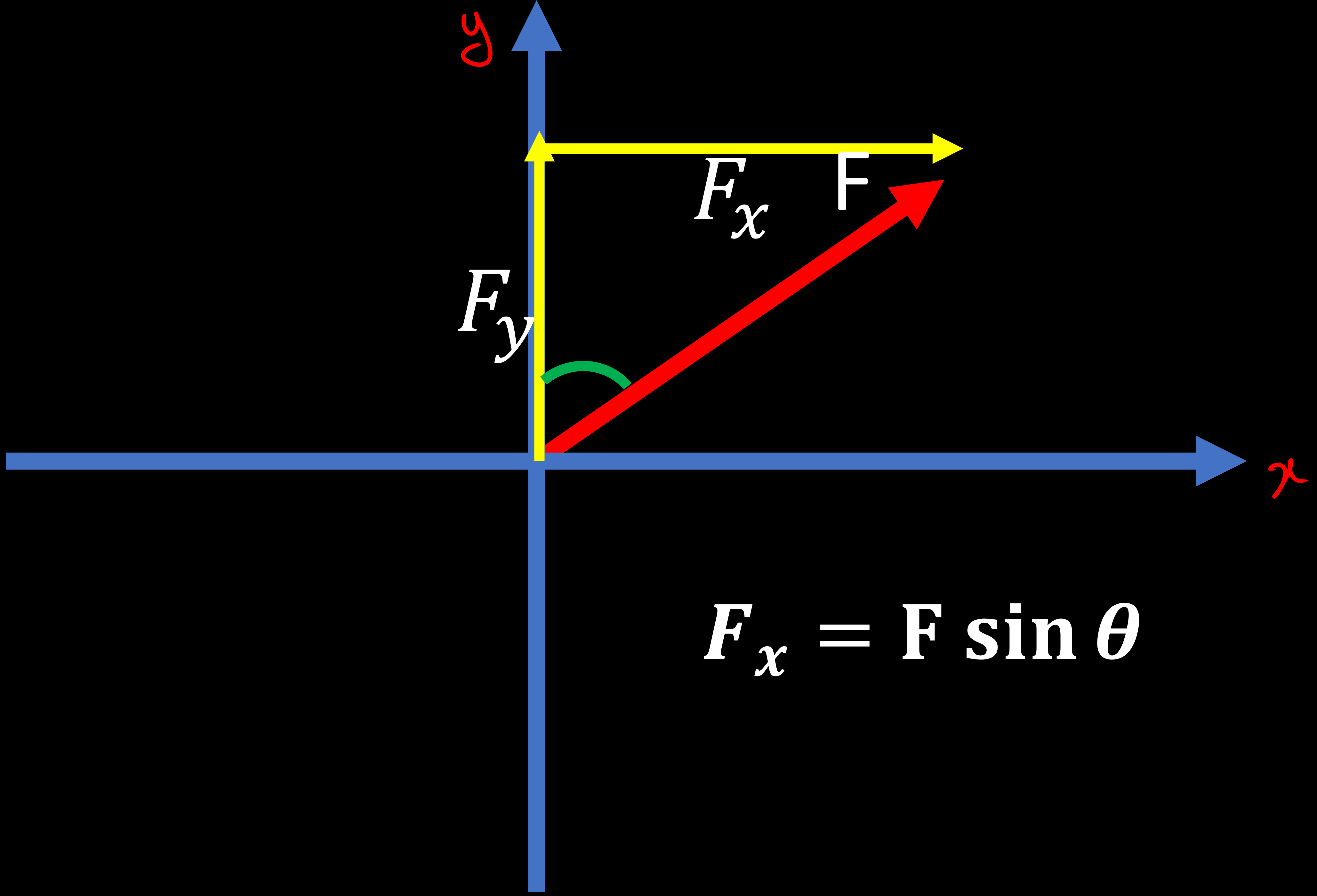
$ma = [40 \cos 30 - 0.3(78.1)]$

$a = \frac{1}{10}(11.21) = 1.12\, ms^{-2}$

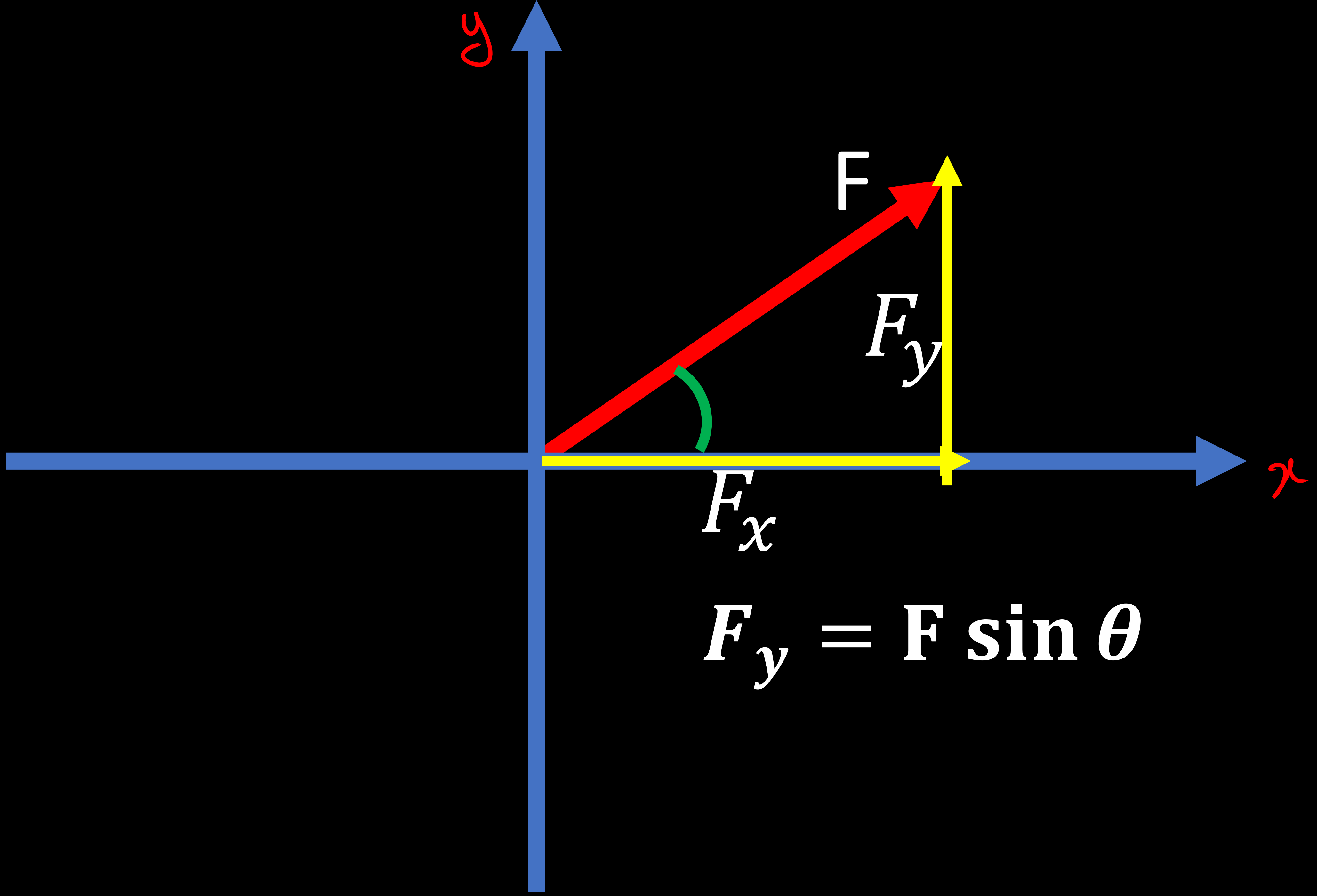




$$F_y = F \sin\theta$$



$$F_x = \mathbf{F}\sin\theta$$



$$F_y = \mathbf{F} \sin \theta$$

Sarawak - 1,216 (84,603)

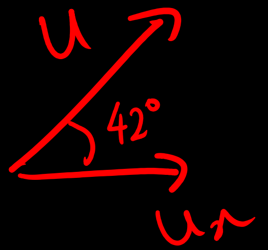
KES COVID BARU HARI INI

1. A javelin is thrown with a speed of $198kmh^{-1}$ at an angle of 42^o with the horizontal. Calculate the velocity of the javelin after $5s$. **[6 marks]**

2. A truck starts from rest and moves with a constant acceleration of $5ms^{-2}$. Find its speed and the distance travelled after $4s$ has elapsed. **[4 marks]**

$$u = 198kmh^{-1} = \frac{198 \times 10^3 m}{60 \times 60 s} = \frac{198000}{3600} ms^{-1} = 55 ms^{-1}$$

$$\theta = 42^\circ$$



x |

$$u_x = u\cos\theta$$

$$u_x = u\cos\theta = (55 ms^{-1})\cos 42^\circ$$

$$u_x \approx 40.87 ms^{-1}$$

$$a_x = 0$$

$$\boxed{V_x = u_x \approx 40.87 ms^{-1}}$$

y |

$$u_y = u\sin\theta$$

$$\underline{u_y \approx 36.8 ms^{-1}}$$

$$a_y = -g$$

$$V_y = u_y + a_y t$$

$$= 36.8 - 9.81(5)$$

$$V_y \approx -12.25 ms^{-1}$$

1. A javelin is thrown with a speed of $198kmh^{-1}$ at an angle of 42^o with the horizontal. Calculate the velocity of the javelin after $5s$. **[6 marks]**

2. A truck starts from rest and moves with a constant acceleration of 5ms^{-2}. Find its speed and the distance travelled after $4s$ has elapsed. **[4 marks]**

$$V^2 = V_x^2 + V_y^2$$

$$V = \left(V_x^2 + V_y^2\right)^{1/2}$$

$$= \left(40.87^2 + (-12.25)^2\right)^{1/2}$$

$$= 42.67\,\text{ms}^{-1}$$

magnitude

$$\tan\theta = \frac{V_y}{V_x}$$

$$\theta = \tan^{-1}\left(\frac{-12.25}{40.87}\right)$$

$$= -16.69^\circ$$

Direction

16.69° below the horizontal!

x-axis

1. A javelin is thrown with a speed of $198kmh^{-1}$ at an angle of 42^o with the horizontal. Calculate the velocity of the javelin after $5s$. **[6 marks]**

2. A truck starts from rest and moves with a constant acceleration of 5ms^{-2}. Find its speed and the distance travelled after $4s$ has elapsed. **[4 marks]**

Common mistake

$$V_y = \underbrace{198 \sin 42}_{kmh^{-1}} + \underbrace{(\overset{ms^{-2}}{-9.81})(\overset{s}{5})}_{ms^{-1}}$$

1. A javelin is thrown with a speed of $198kmh^{-1}$ at an angle of 42^o with the horizontal. Calculate the velocity of the javelin after $5s$. **[6 marks]**

2. A truck starts from rest and moves with a constant acceleration of 5ms^{-2}. Find its speed and the distance travelled after $4s$ has elapsed. **[4 marks]**

$$\frac{9.81m}{1s} \Rightarrow kmh^{-1}$$

1. A javelin is thrown with a speed of $198kmh^{-1}$ at an angle of 42^o with the horizontal. Calculate the velocity of the javelin after $5s$. **[6 marks]**

2. A truck starts from rest and moves with a constant acceleration of $5ms^{-2}$. Find its speed and the distance travelled after $4s$ has elapsed. **[4 marks]**

2) $\Delta V \neq 0$

$a > 0$

$u = 0ms^{-1}$

$V(t=4) = u + at$

$V = 0 + (5)(4)$

$= 20ms^{-1}$

$S = ut + \frac{1}{2}at^2 \rightarrow S = 0 + \frac{1}{2}(5)(4^2)$

$V^2 = u^2 + 2as$

$V^2 - u^2 = 2as$

$S = \frac{V^2 - u^2}{2a}$

$= \frac{20^2 - 0^2}{2(5)} = 40m$

1

$S = 40m$

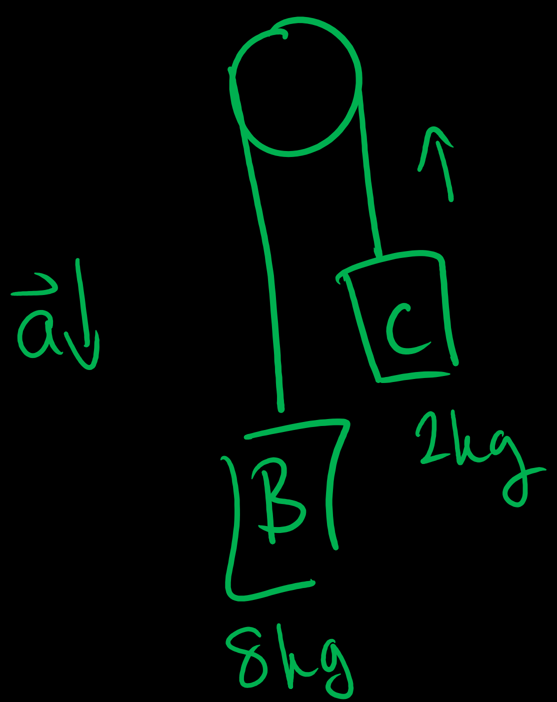
2

16 August 2021
Monday 8pm

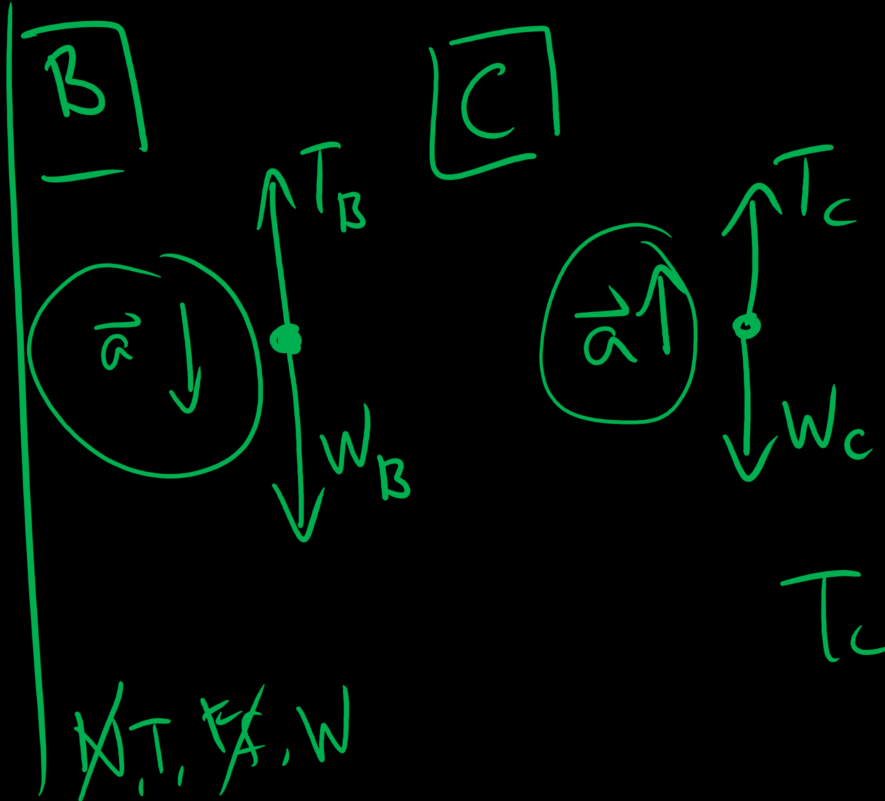
Problem 1

A light inextensible string passes over a smooth light pulley. At each end of the string there is a particle. Particle B has a mass of 8 kg and particle C has a mass of 2 kg as shown in the diagram. The particles are released from rest with the string taut. Calculate the tension in the string and the acceleration of the masses.

Diagram



FBD



$W_B - T_B = \sum F = m_B a$

$T_C - W_C$ — ①

$\cancel{W_C - T_C}$ — ②

$T_C - W_C = \sum F = m_C a$

Problem 1

Simultaneous equations

A light inextensible string passes over a smooth light pulley. At each end of the string there is a particle. Particle B has a mass of 8 kg and particle C has a mass of 2 kg as shown in the diagram. The particles are released from rest with the string taut. Calculate the tension in the string and the acceleration of the masses.

$$W_B - T_B = m_B a$$

$$T_C - \boxed{W_C} = m_C a \quad -②$$

$$W = mg$$

$$W_i = m_i g$$

$$T_B = T_C = T$$

$$\boxed{T = T_B = W_B - m_B a} \quad -①$$

$$T = T_C = m_C a + W_C$$

① into ②

$$[W_B - m_B a] \boxed{- W_C} = m_C a$$

$$W_B - W_C = a(m_C + m_B)$$

$$a = \frac{W_B - W_C}{m_C + m_B} = \frac{(m_B - m_C)g}{m_C + m_B} = \frac{8-2}{8+2}(9.81)$$

$$a \simeq 5.886 \ ms^{-2}$$

Problem 1

A light inextensible string passes over a smooth light pulley. At each end of the string there is a particle. Particle B has a mass of 8 kg and particle C has a mass of 2 kg as shown in the diagram. The particles are released from rest with the string taut. Calculate the tension in the string and the acceleration of the masses.

$$T = W_B - m_B a$$

$$= m_B g - m_B a$$

$$= m_B (g - a)$$

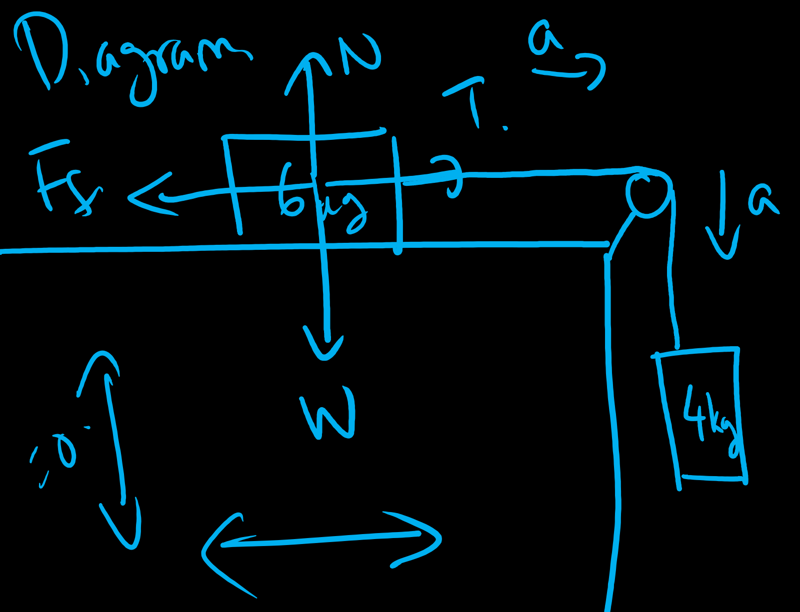
$$= 8(9.81 - 5.886)$$

$$= 31.392 N$$

Problem 2

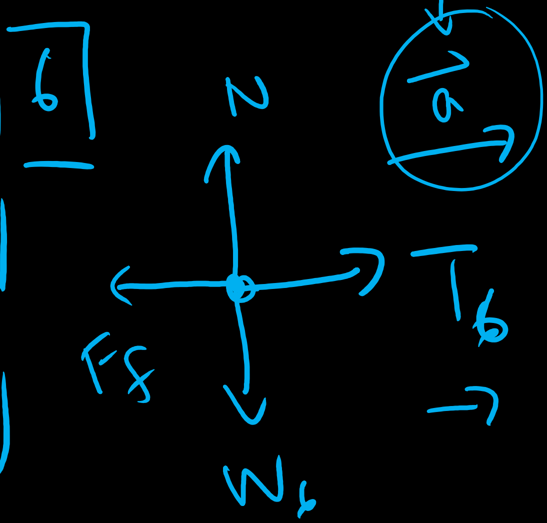
A box, of mass 6 kg, is sliding along a rough horizontal table. It is connected to another box of mass 4 kg, via a light inextensible string, which passes over a smooth light pulley (as shown in the diagram). Given that the coefficient of sliding friction between the table and the box is 0.3, what is the acceleration of each particle and what is the tension in the string?

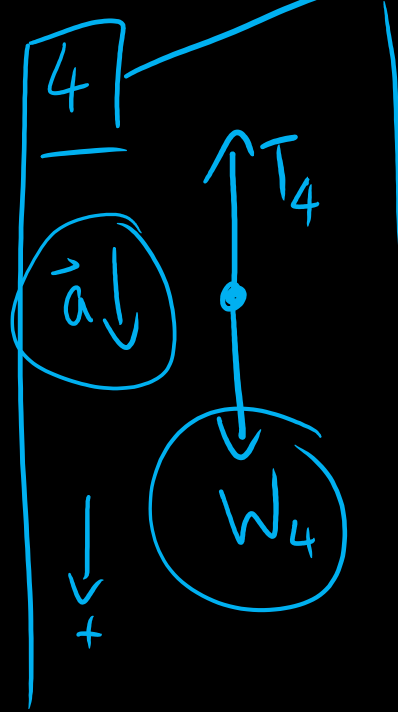
Diagram



N, T, Fs, W

FBD





$ma = W_4 - T_4 = \sum F$ (1)

$F_{y6} = 0 = N - W_6$

$N = W_6 = m_6 g$ } 6

$F_f = \mu_k m_6 g$

$m_6 a = T_6 - F_f$ $\boxed{6}$

$T_4 = T_6 = T.$

Problem 2

Simultaneous eqn.

A box, of mass 6 kg, is sliding along a rough horizontal table. It is connected to another box of mass 4 kg, via a light inextensible string, which passes over a smooth light pulley (as shown in the diagram). Given that the coefficient of sliding friction between the table and the box is 0.3, what is the acceleration of each particle and what is the tension in the string?

$$m_4 a = W_4 - T_4 \quad (1)$$

$$m_6 a = T_6 - F_f \quad (2)$$

$$W_4 = m_4 g$$

$$W_6 = m_6 g$$

$$F_f = \mu_k m_6 g$$

$(1) \Rightarrow$ ~~$m_4 a$~~

$$T_6 = T = T_4 = W_4 - m_4 a \quad (3)$$

(3) into (2).

$$m_6 a = W_4 - m_4 a - \mu_k m_6 g$$

$$(m_6 + m_4) a = W_4 - \mu_k m_6 g$$

$$a = \frac{W_4 - \mu_k m_6 g}{m_6 + m_4} = \frac{m_4 g - \mu m_6 g}{m_6 + m_4}$$

$$a = \frac{(9.81)(4 - 0.3(6))}{6 + 4}$$

$$a \approx 2.158 \text{ ms}^{-2}$$

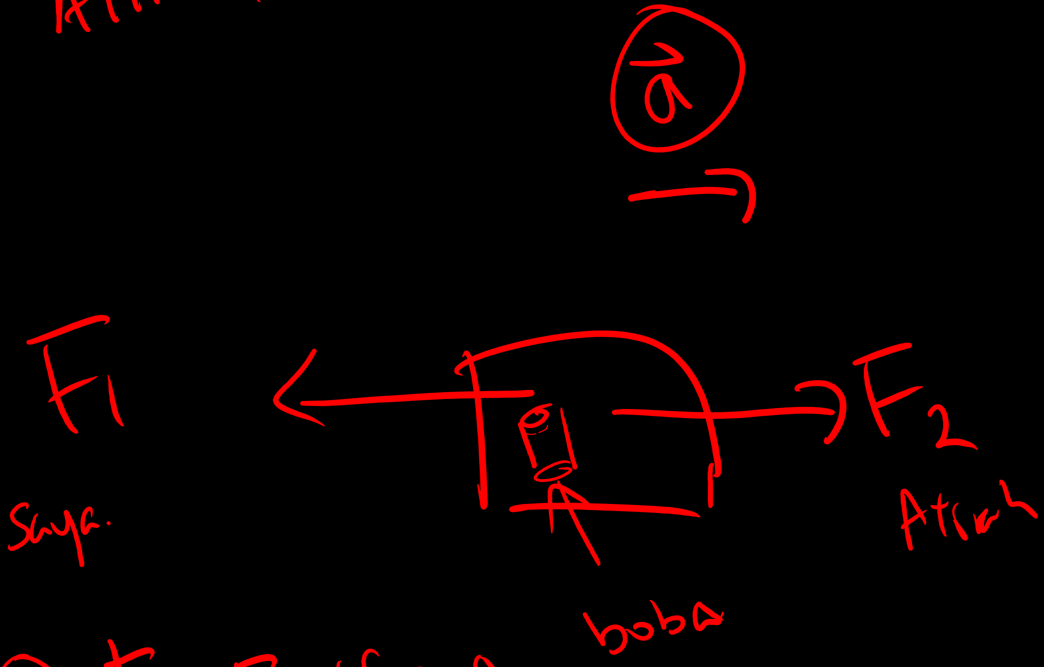
$$T = m_4 g - m_4 a$$

$$= 4(9.81 - 2.1582)$$

$$= 30.6072 \text{ N}$$

KOTAK

ATIRAH.



① $F_1 = F_2$ if $a = 0$.

② $\sum F = ma = F_2 - F_1$

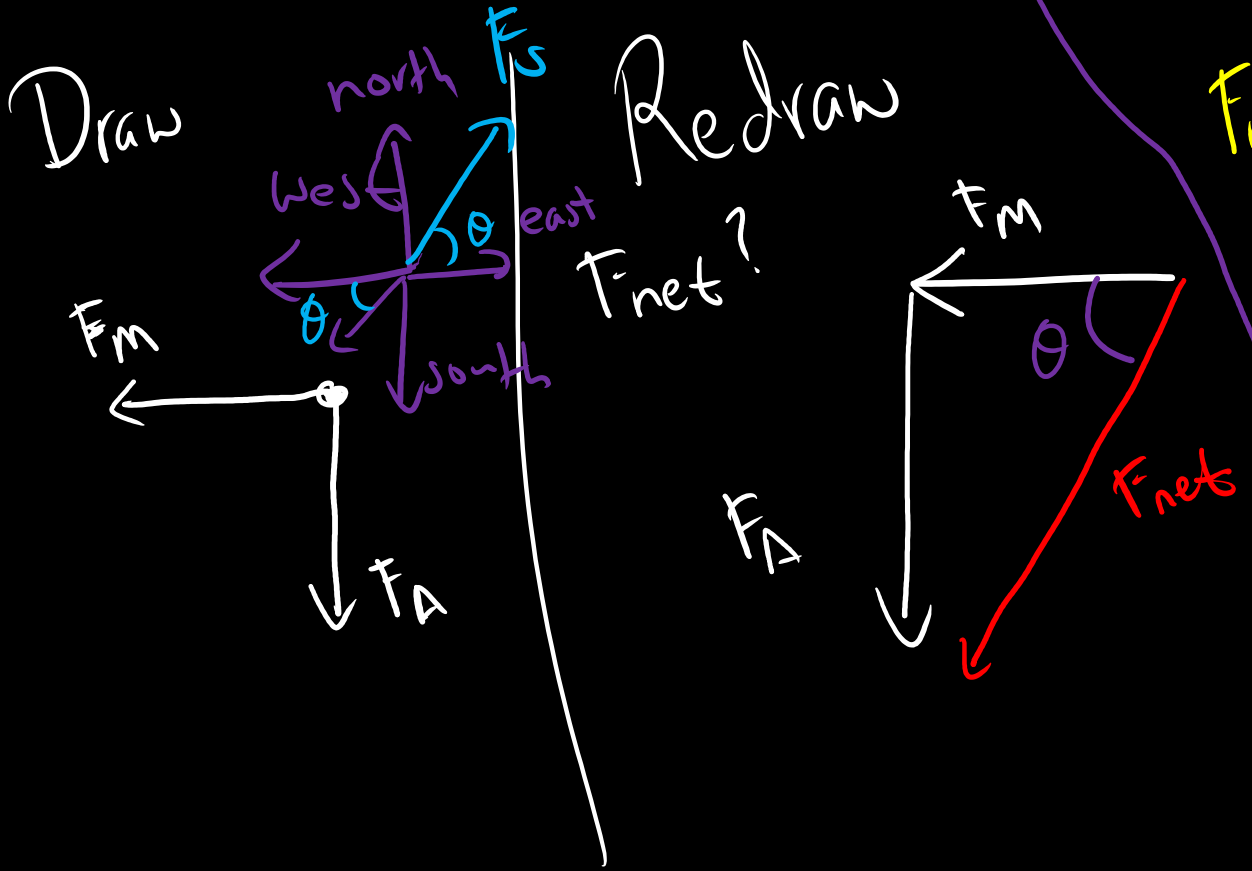
if $a \neq 0$

$\sum F = F_{net}$

4.2 Newton's Laws of Motion

$$(x)^{1/2} = \sqrt{x}$$

1. Syafiee, Akmal and Masnah find three ropes tied together with a single knot and decide to have three-way tug-of-war. Masnah pulss to the west with 100 N of force while Akmal pulls to the south with 200 N. How hard, and in which direction, should Syafiee pull to keep the knot from moving?



$$F_{net} = \left(F_M^2 + F_A^2\right)^{1/2}$$

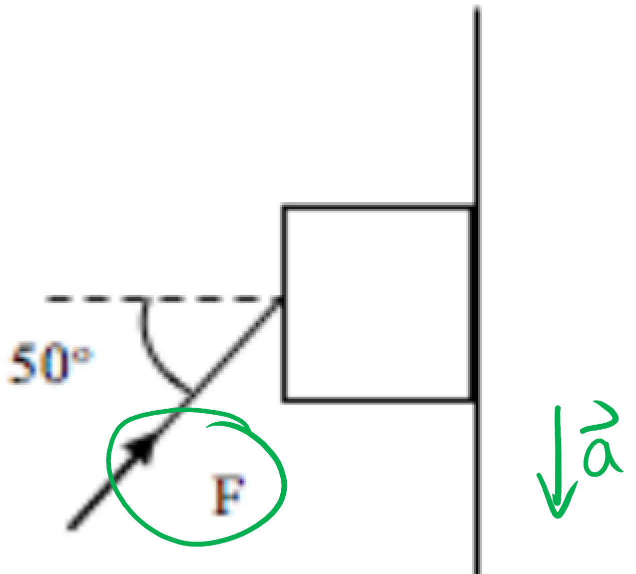
$$= \left(100^2 + 200^2\right)^{1/2}$$

$$= 223.61\ N$$

$$\tan\theta = \frac{F_A}{F_M}$$

$$\theta = \tan^{-1}\left(\frac{200}{100}\right) \approx 63.43^\circ$$

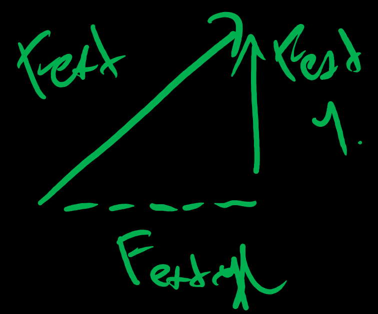
3. A block of mass 3.00 kg is pushed up against a wall by a force F that makes a 50^0 angle with the horizontal as shown in figure.



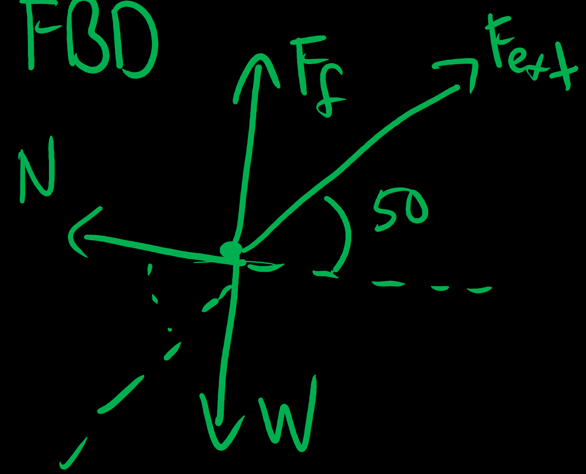
The coefficient of static friction between the block and the wall is 0.250.

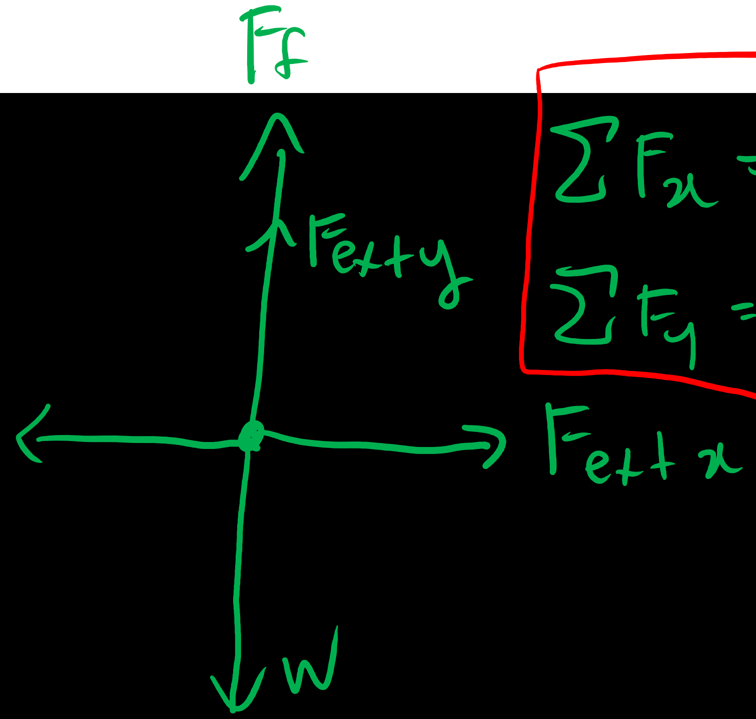
Determine the possible values for the magnitude of F that allows the block to remain stationary.

N, T, F_f, W
✓ ✗ ✓ ✓



FBD





$$\boxed{\begin{aligned} \sum F_x &= N - F_{ext\,x} \\ \sum F_y &= W - F_f - F_{ext\,y} \end{aligned}}$$

Thank you!

17 August 2021 Session

Labs

Lab Manual

air friction is negligible

FREE FALL MOTION

LEARNING OUTCOMES

At the end of this lesson, students should be able to:

i. determine the acceleration due to gravity, g using free fall motion.

THEORY

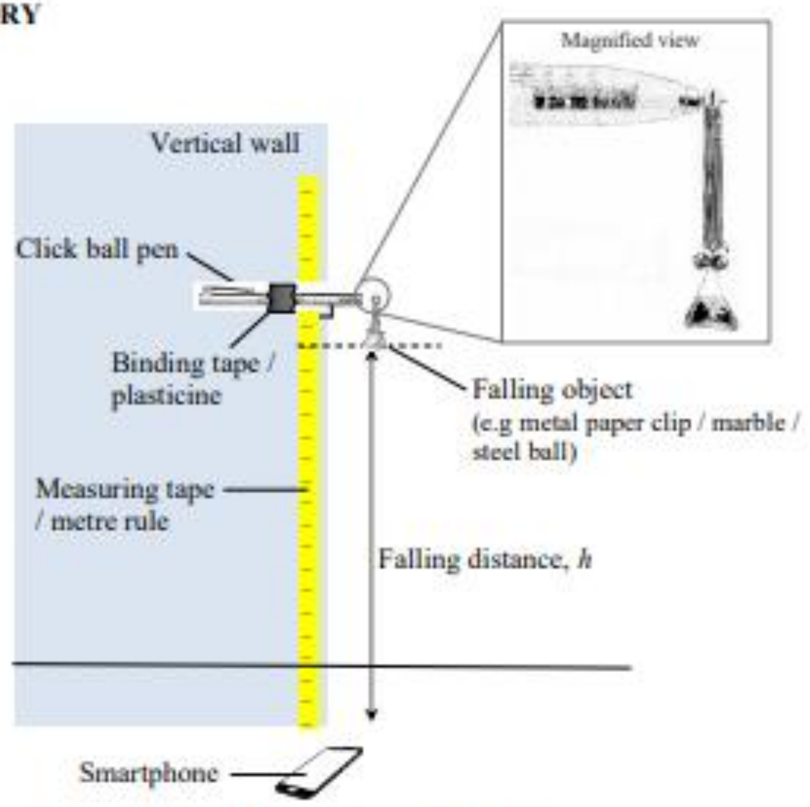


Figure 3.2 Experiment Free Fall Motion Set Up

When a body of mass, m falls freely from a certain height, h above the ground, it experiences a linear motion. The body will obey the equation of motion,

$$\boxed{s = ut + \frac{1}{2}at^2} \qquad 3.4$$

By substituting the following into equation 3.4,

$s = -h$ (downward displacement of the body from the falling point to the ground)

$u = 0$ (the initial velocity of the body)

$a = -g$ (the downward acceleration due to gravity)

we obtain

$$\boxed{h = \frac{1}{2}gt^2} \qquad 3.5$$

Phyphox. app

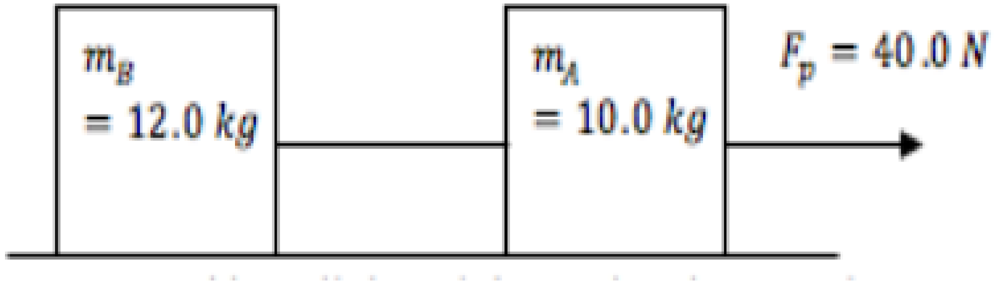
App Store (iOS) Play Store (Android)

Lab Report Submission!

Tutorials

Example problem 1

6. Two boxes, A and B are connected by a lightweight cord and are resting on smooth table. The boxes have masses 10.0 kg and 12.0 kg.



A horizontal force of 40.0 N is applied to 10.0 kg box. Calculate:

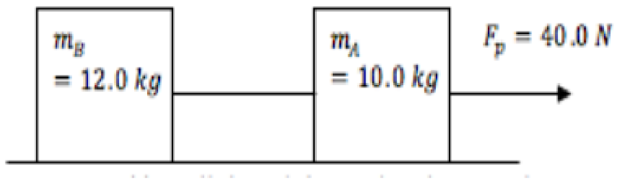
a) The acceleration of each box

$1.82 ms^{-2}$

b) The tension in the cord connecting the box 21.84N

Example problem 1

6. Two boxes, A and B are connected by a lightweight cord and are resting on smooth table. The boxes have masses 10.0 kg and 12.0 kg.

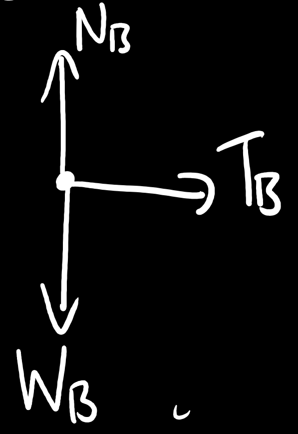


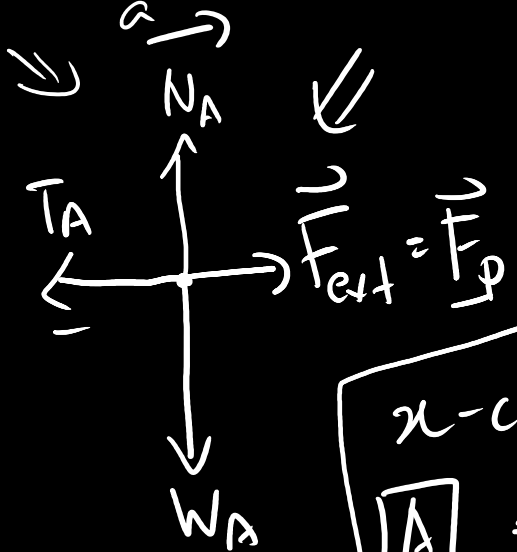
A horizontal force of 40.0 N is applied to 10.0 kg box. Calculate:

a) The acceleration of each box

b) The tension in the cord connecting the box

2 FBD





x-component

$\boxed{A}$ $\sum F_x = m_A a = \vec{F}_p - T_A = \vec{F}_p - T$

$\boxed{B}$ $\sum F_x = \boxed{m_B a} = T_B = T$

$T_B = T_A = T$.

$\sum F_y = 0$

$N_B = W_B ; N_A = W_A$.

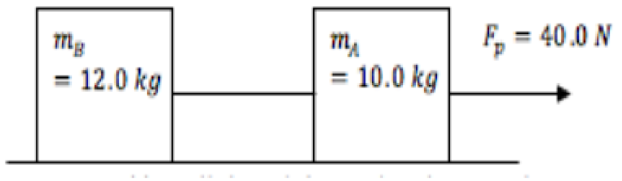
$m_A a = F_p - m_B a$.

$a(m_A + m_B) = F_p$

$$a = \frac{F_p}{m_B + m_A} = \frac{40}{12+10} = \boxed{1.82\, ms^{-2}}$$

Example problem 1

6. Two boxes, A and B are connected by a lightweight cord and are resting on smooth table. The boxes have masses 10.0 kg and 12.0 kg.



A horizontal force of 40.0 N is applied to 10.0 kg box. Calculate:

a) The acceleration of each box

b) The tension in the cord connecting the box

$m_B a = T.$

$(12kg)(1.82) = T$

$T = 21.84N$ #

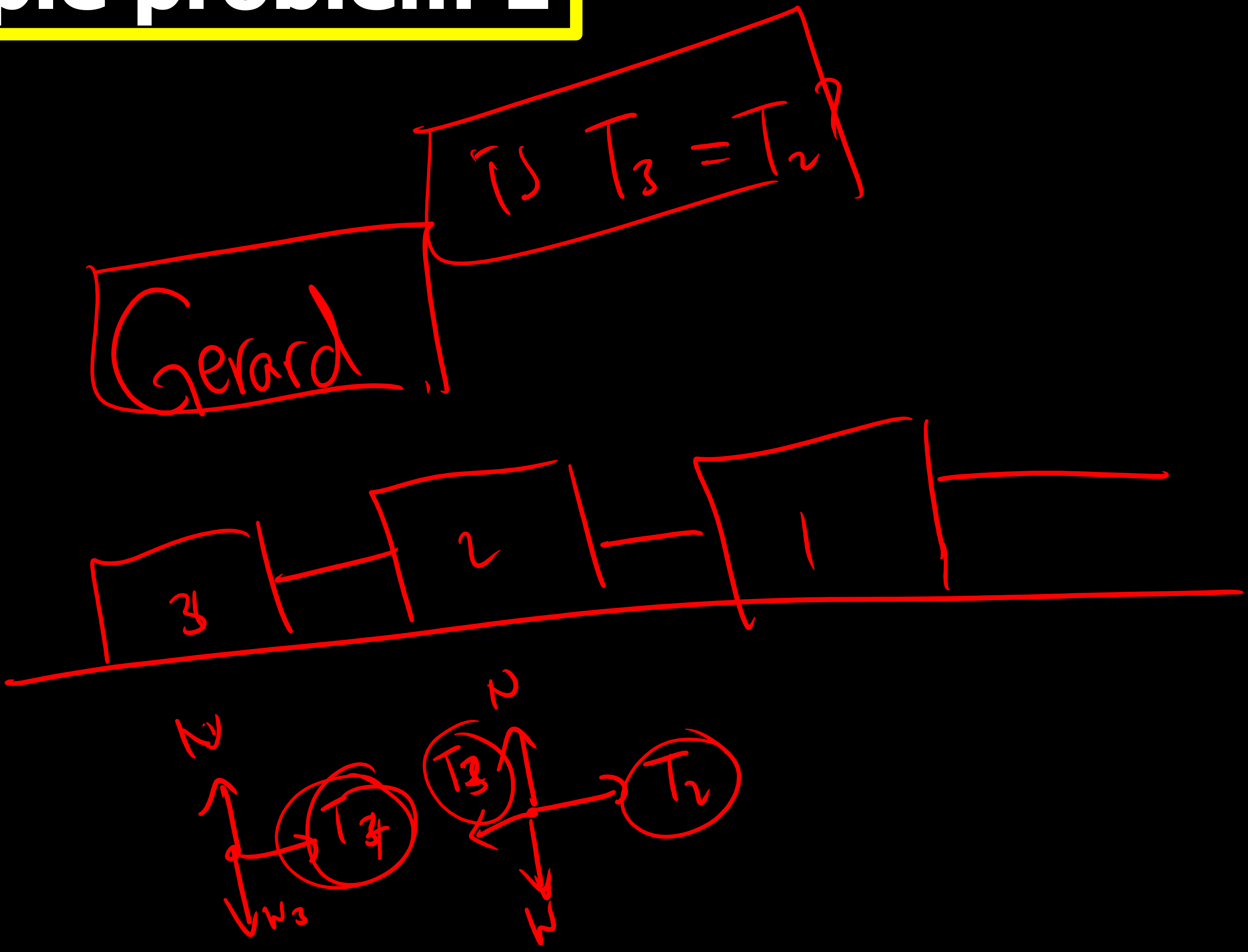
$m_A a = F_p - T.$

$10(1.82) = 40 - T$

$T = 40 - 18.2$

$= 21.8N$

Example problem 1



Example problem 2

A box of mass M = 10 Kg rests on a 35° inclined plane with the horizontal. A string is used to keep the box in equilibrium. The string makes an angle of 25 ° with the inclined plane. The coefficient of friction between the box and the inclined plane is 0.3.

a) Draw a Free Body Diagram including all forces acting on the particle with their labels.

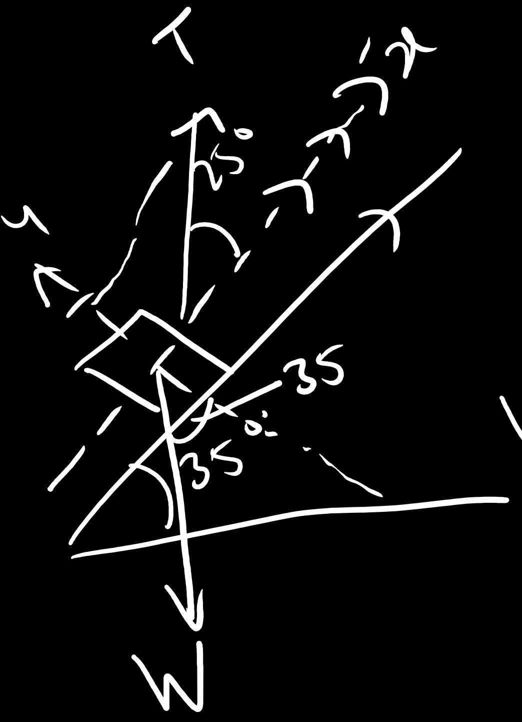
b) Find the magnitude of the tension T in the string.

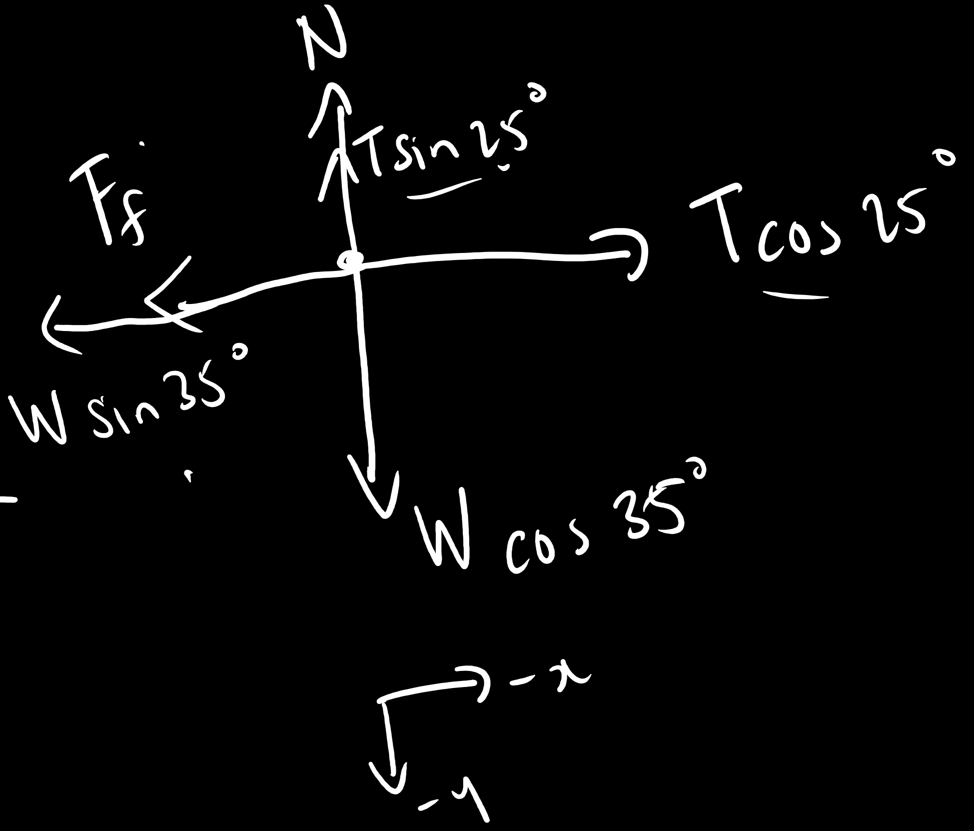
c) Find the magnitude of the force of friction acting on the particle.

Example problem 2

A box of mass M = 10 Kg rests on a 35° inclined plane with the horizontal. A string is used to keep the box in equilibrium. The string makes an angle of 25 ° with the inclined plane. The coefficient of friction between the box and the inclined plane is 0.3.

a) Draw a Free Body Diagram including all forces acting on the particle with their labels.





$$\sum F_x = 0 = T\cos 25 - F_f - W\sin 35$$

$$\sum F_y = 0 = N + T\sin 25 - W\cos 35$$

Example problem 2

A box of mass M = 10 Kg rests on a 35° inclined plane with the horizontal. A string is used to keep the box in equilibrium. The string makes an angle of 25 ° with the inclined plane. The coefficient of friction between the box and the inclined plane is 0.3.

b) Find the magnitude of the tension T in the string.

$$T\cos 25 - F_f - W\sin 35 = 0$$

$$N + T\sin 25 - W\cos 35 = 0$$

$$T\cos 25 = F_f' + W'\sin 35$$

$$T\sin 25 = W'\cos 35 - N'$$

$$F_f = \mu N$$

$$N = W\cos 35 - T\sin 25$$

$$F_f = \mu(W\cos 35 - T\sin 25)$$

$$T\cos 25 = \mu'(W'\cos 35 - T\sin 25) + W'\sin 35 \quad (1)$$

$$T\sin 25 = W'\cancel{\cos}35 - W'\cancel{\cos}35 + T\sin 25 \quad \cancel{(2)}$$

Example problem 2

A box of mass M = 10 Kg rests on a 35° inclined plane with the horizontal. A string is used to keep the box in equilibrium. The string makes an angle of 25 ° with the inclined plane. The coefficient of friction between the box and the inclined plane is 0.3.

b) Find the magnitude of the tension T in the string.

$$T\cos 25 = \mu W \cos 25 - \mu T \sin 25 + W \sin 25$$

$$T[\cos 25 + \mu \sin 25] = W[\mu \cos 25 + \sin 25]$$

$$T = \frac{W[\mu \cos 25 + \sin 25]}{\cos 25 + \mu \sin 25} = \frac{98.1[0.3(0.906) + 0.4226]}{0.906 + 0.3(0.4226)}$$

$$T = 65.949\text{N}$$

Example problem 2

A box of mass M = 10 Kg rests on a 35° inclined plane with the horizontal. A string is used to keep the box in equilibrium. The string makes an angle of 25 ° with the inclined plane. The coefficient of friction between the box and the inclined plane is 0.3.

c) Find the magnitude of the force of friction acting on the particle.

$$F_f = \mu(W\cos 35 - T\sin 25)$$

$$= 0.3(98.1(0.819) - 65.95(0.4226))$$

$$\approx 15.74\,N$$

Thank you !

18 August 2021

2pm Session

Chapter 5

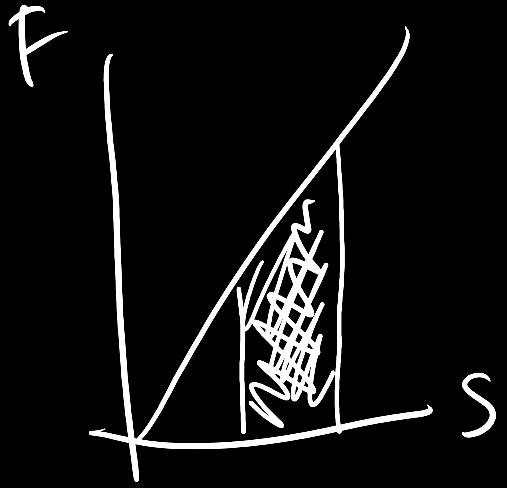
Definitions

Work; $W = \vec{F} \cdot \vec{s}$

displacement

multiplication

force



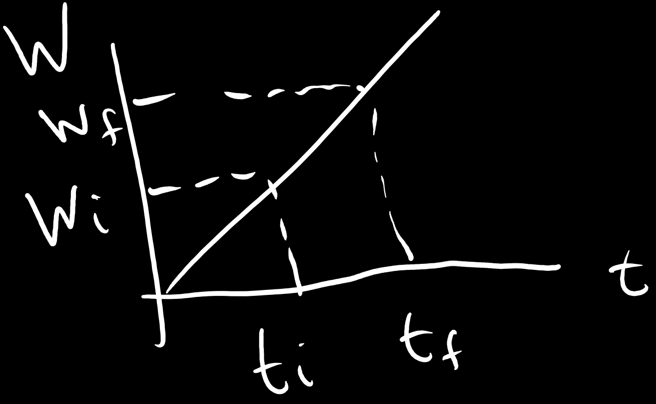
area ⇐ W

~~gradient~~

Power

average, 'between'

$$P = \frac{\Delta W}{\Delta t} = \frac{W_f - W_i}{t_f - t_i}$$



instantaneous 'at'

$$P = \frac{dW}{dt} = \frac{d}{d}(F \cdot s) \Longrightarrow P_{inst.} = F \cdot \frac{ds}{dt} = F \cdot \vec{v}$$

assume $\Delta F = 0$

Conservation of Energy

Concept #1

$$\Delta E = \boxed{0 = E_f - E_i}$$

$$E_f - E_i = 0$$

$$E_f = E_i$$

Total energy

$E_k = \frac{1}{2}mv^2$

$E_{gp} = mgh$

$E_{ep} = \frac{1}{2}kx^2$

$F = kx$

$E_c = mc\theta = ml$

combined until kira total.

$E_T = E_i = mgh_i$

$i: 0$

$E_T = mgh_f$

$f: 0 + \frac{1}{2}mv^2$

Ground

Work-Energy Theorem

Concept # 2

$F = ma$

$E_k = \frac{1}{2}mv^2$

$kg(ms^{-1})^2$

$\boxed{kg m^2 s^{-2}}$

$W = Fs$

$\Rightarrow kg ms^{-2} \, m$

$\Rightarrow \boxed{kg m^2 s^{-2}}$

Same unit

$\Downarrow$

Same 'thing'

$\cancel{\Delta K}$ $\Delta E_k = W$

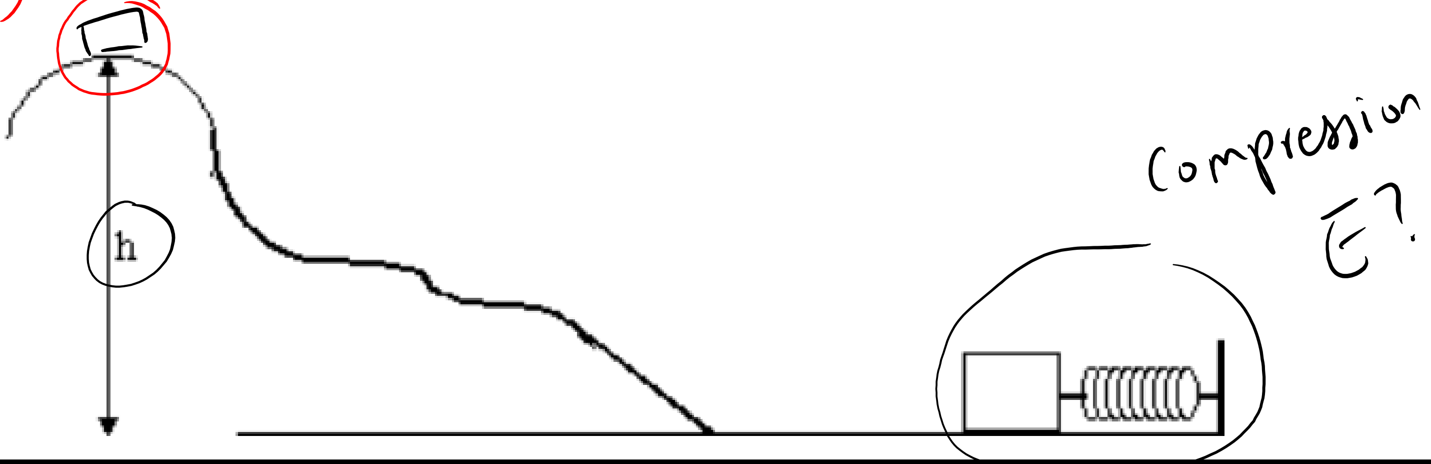
Sample Problem 1

In the diagram below, the spring has a force constant of 5000 N/m, the block has a mass of 6.20 kg, and the height h of the hill is 5.25 m. Determine the compression of the spring such that the block just makes it to the top of the hill. Assume that there are no non-conservative forces involved.

k

m

no velocity bila sampai top.



$i \qquad f$

$E_{ep} \rightarrow E_{gp}$

$E_{ep} = \frac{1}{2}kx^2$

$E_{gp} = mgh$

$E_{ep} = E_{gp}$

$\frac{1}{2}kx^2 = mgh$

$x^2 = \frac{2mgh}{k}$

$x = \left(\frac{2mgh}{k}\right)^{1/2}$

$x = \left(\frac{2 \times 6.2 \times 9.81 \times 5.25}{5000}\right)^{1/2}$

$x \approx 0.3574\ m$

Sample Problem 2

h   t

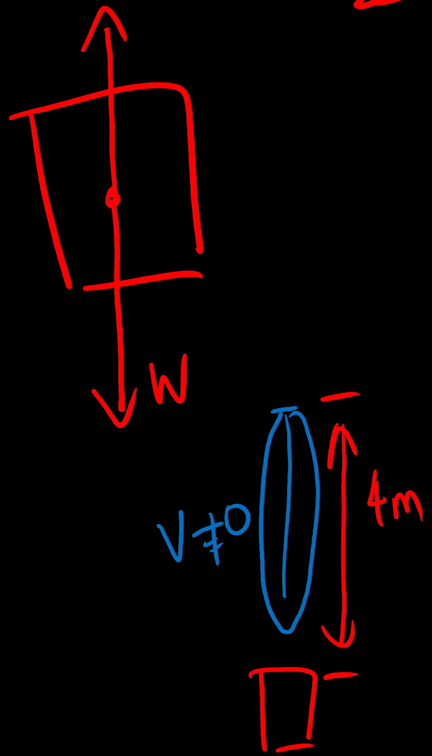
A lift motor has to move a fully laden lift 4m between floors in 1.5s. The lift has a mass of 1850kg (ignore friction).

What is the minimum power of the motor to raise the lift at a steady speed?

$\cancel{\Delta E} = a = 0$

if $\Delta h \neq 0$

then $\Delta E_{gp} \neq 0$



$$\Delta E_{gp} = mg\,\Delta h$$
$$= 1850 \times 9.81 \times 4$$
$$= 72594\ \text{J}$$

W-E theorem

$$W = \Delta E_k = \Delta E_{gp}$$

work done

work done

$$P = \frac{\Delta W}{\Delta t} = \frac{W}{\Delta t} = \frac{72594\ \text{J}}{1.5\ \text{s}}$$

$$\boxed{P = 48396\ \text{J s}^{-1}}$$

Things you must have in lab report.

- Objective
- Hypothesis
- Literature review ("introduction/theory")
- Methodology (Material & Procedure)
- Data Tabulation
- Data Analysis (kira gradient & uncertainty)
- Discussions
- Conclusion

Thank you!

19 August 2021
2pm Session

Sample Problem 1

$\cos 90 = 0$

$$W = F \cdot s$$

$$W_T = W_{F_{ext}} + W_w + \cancel{W_f}^{\,0} + \cancel{W_T}^{\,0} + \cancel{W_N}^{\,0}$$

$$W_{F_{ext}} = \vec{F}_{ext} \cdot \vec{s}$$

$$= |\vec{F}_{ext}|\,|\vec{s}| \cos\theta$$

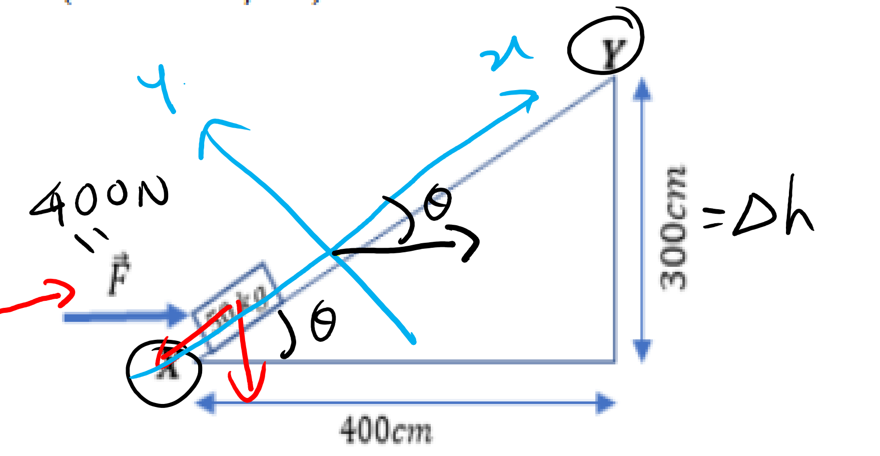
$$\theta = \tan^{-1}\left(\frac{300}{400}\right)$$

$$\theta \approx 36.87^\circ$$

$$= (400)(5m) \cos 36.87^\circ$$

$$\approx 1600\,J$$

1. (PSPS 01/02)



The figure above shows a horizontal force, $\vec{F}$, pushing a safe of mass $50kg$ on a smooth inclined plane from position X to position Y. If $|\vec{F}|$ is 400 N, calculate

(a) the work done to move the safe (in Joule)

(b) the potential energy at position Y.

$$W_{F_{ext}} \approx 1600\,J$$

Sample Problem 1

$\angle sW = 126.87^\circ$

$\angle$ hl weight $= 90.0^\circ$

work done, weight

$$W_{weight} = W \cos \underbrace{126.87}_{90+36.87}$$

$$= mgs \cos 126.87$$

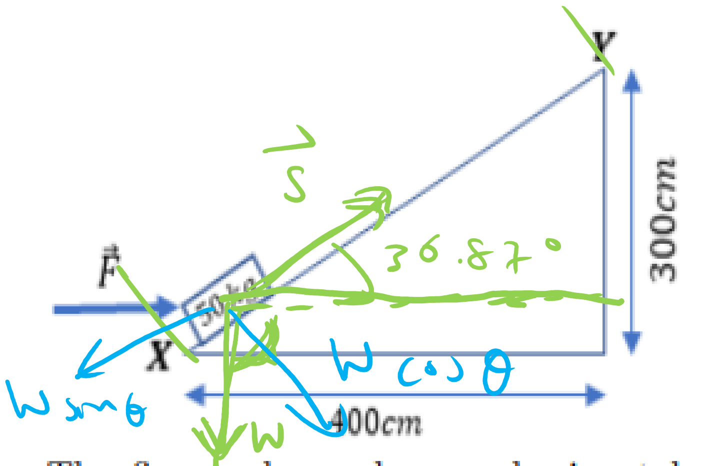
$$= 50(9.81)(\cos 126.87) \times 5$$

$$= \cancel{29430}\ 294.3 \times 5$$

$$= \boxed{-1471.5\ J.}$$

negative sebab W (weight) $\sin\theta$ is opposite to $\vec{s}$

1. (PSPS 01/02)



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(a) the work done to move the safe (in Joule)

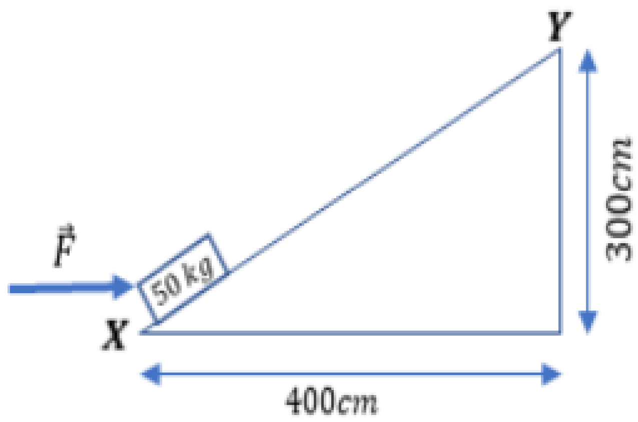
(b) the potential energy at position Y.

Sample Problem 1

$$W_T = W_{Fext} + W_w$$
$$= 1600 + (-1471.5)$$
$$= 128.5\,J \ \#$$

Final answer!

1. **(PSPS 01/02)**



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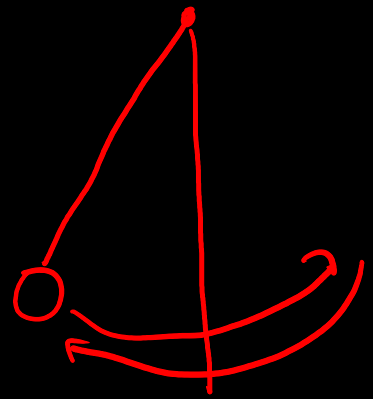
(a) the work done to move the safe (in Joule)
(b) the potential energy at position Y.

Sample Problem 2

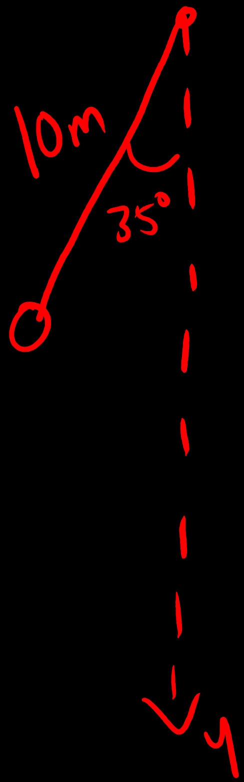
A wrecking ball of mass 600 kg hangs form a crane by a cable of length 10 m. If this wrecking ball is released from an angle of 35 degrees, what will be its kinetic energy when it swings through the lowest point of the arc?

$m = 600\,kg$ | $\theta = 35^\circ$

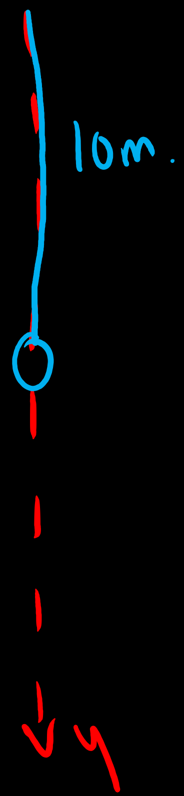
$l = 10\,m$

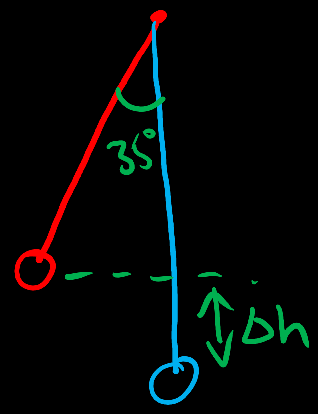


initial.



final





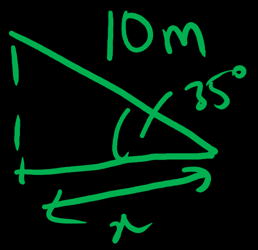
$E_{gp} \rightarrow E_k$

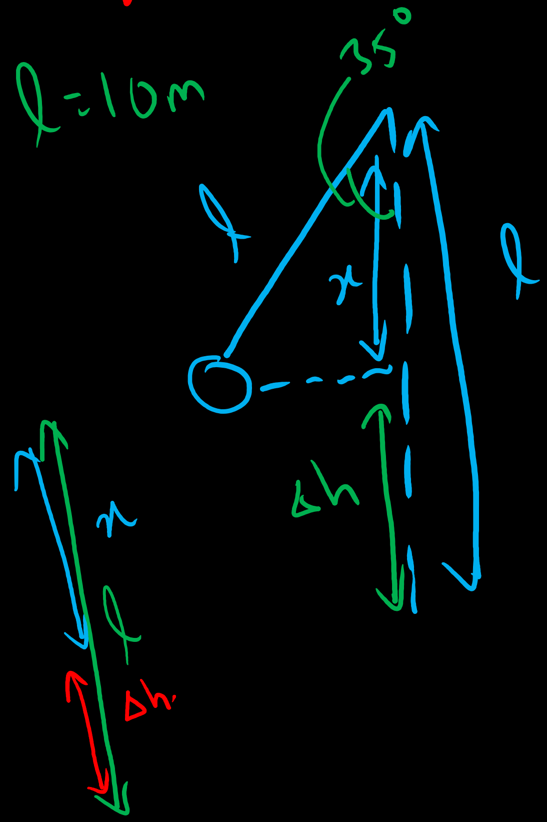
Sample Problem 2

A wrecking ball of mass 600 kg hangs form a crane by a cable of length 10 m. If this wrecking ball is released from an angle of 35 degrees, what will be its kinetic energy when it swings through the lowest point of the arc?

$E_{gp} = E_k$

$E_k = mg\Delta h$





Calculate x if $\theta = 35°$?

$x = 10\cos 35 = 8.19\,m$

$\Delta h = 10\,m - 8.19\,m$

$= 1.81\,m$

$E_k = \frac{1}{2}mv^2$

$E_k = mg\Delta h$

$= (600)(9.81)(1.81)$

$E_k = 10653.66\,J$

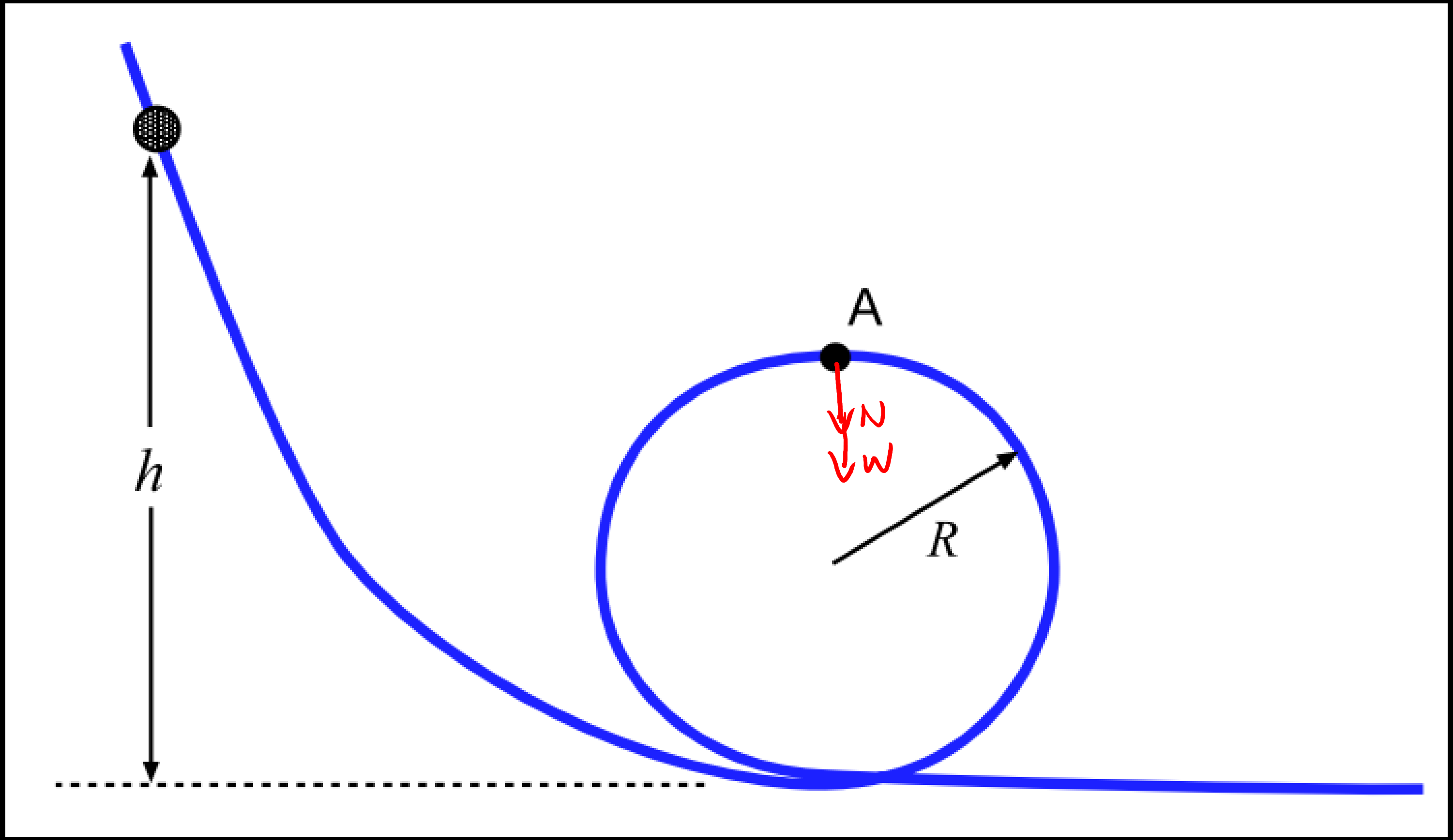
$V = 5.96\,ms^{-1}$

THANK YOU!

20 August 2021
8.30 am session

Sample Problem

A bead slides without friction on a loop–the–loop track (see figure). If the bead is released from a height $h = 3.50R$, what is its speed at point A?



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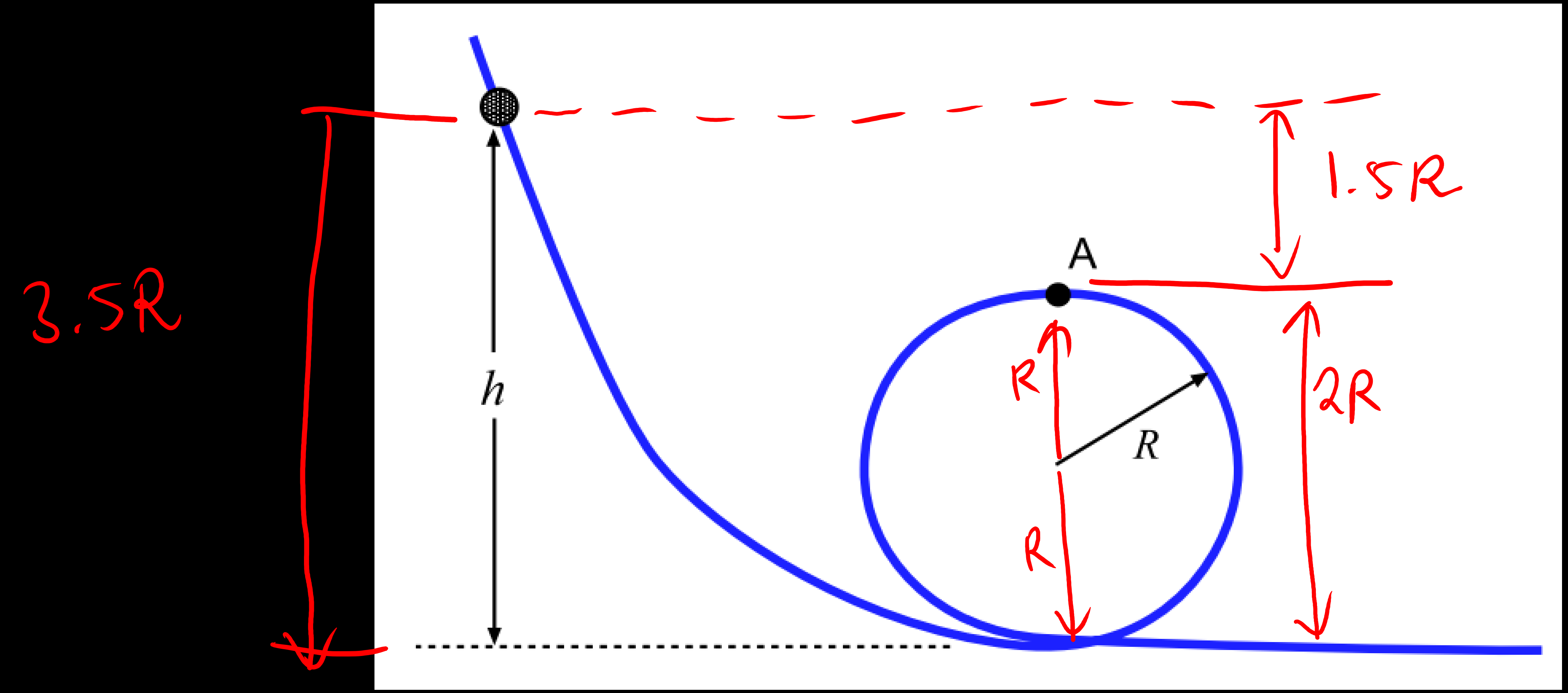

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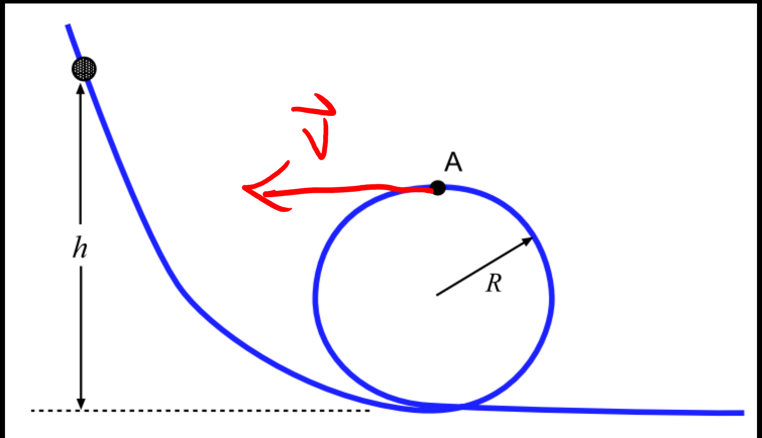


$E_{gp} = E_k$

$\cancel{m} g \Delta h = \frac{1}{2} \cancel{m} (\Delta v^2)$

$g \Delta h = \frac{1}{2}(v^2 - \cancel{u^2})$

$V^2 = 2g\Delta h$

$V = 2g\Delta h$ ##

$1.5R = \Delta h$

$V = 2(9.81)(1.5R)$

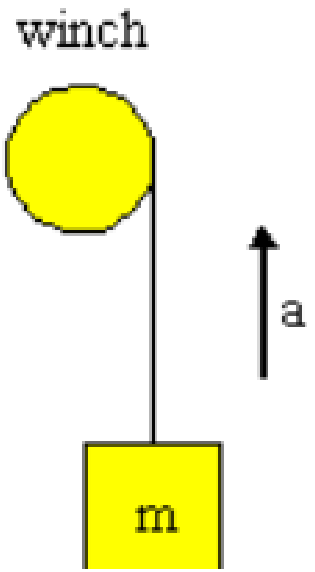
$V = 29.43R \text{ ms}^{-1}$ ##

Thank you!

23rd August 2021
8.15pm session

Sample Problem 1

A winch lifts a 150 kg crate 3.0 m upwards with an acceleration of 0.50 m/s^2. How much work is done by the winch? How much work is done by gravity?



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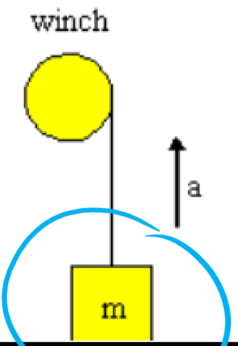


$\cancel{F_f}$, $\cancel{N}$, T, W

weight

$\sum F_y = T - W$

$W = mg$

$ma = T - W$

$T = ma + W$

$T = m(a+g)$

$W = F \cdot s$

work done by tension

tensional.

$W = m(a+g)(s)$

$= 150(9.81 + 0.5)(3)$

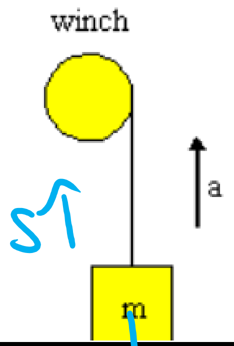
$W = 4639.5\,J$

$W = N \cdot s$

work done by normal.

Sample Problem 1

A winch lifts a 150 kg crate 3.0 m upwards with an acceleration of 0.50 m/s^2. How much work is done by the winch? How much work is done by gravity?



0° F s $1.$

$s\uparrow$ $\downarrow W$

s F $-1.$

dot product

$$W_{gravity} = F \cdot s = |F||s| \cos \theta.$$

$$\text{weight} = mg.$$

$$W_g = mg \cdot s \quad |mg||s| \cos \underbrace{180}_{-1}.$$

$$W_g = -(m)(g)(s)$$

$$= -(150)(9.81)(3)$$

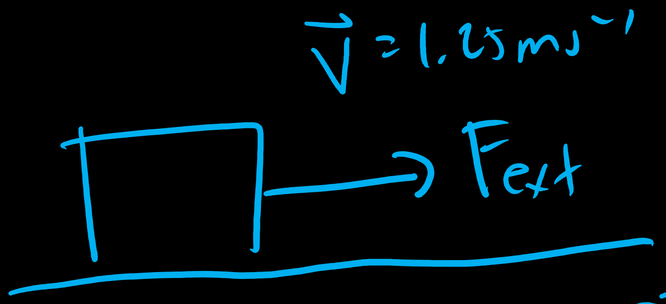
$$W_g = -4414.5\,J \ \#$$

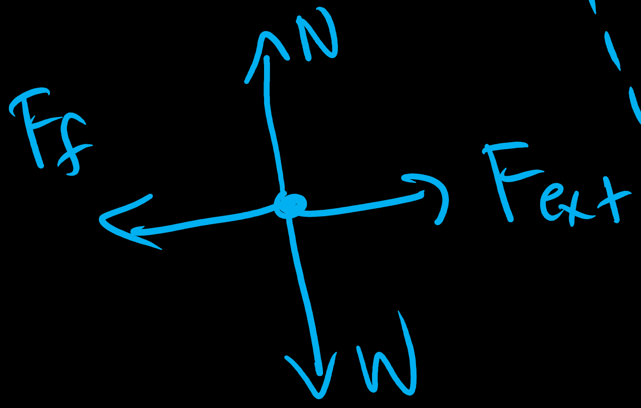
Sample Problem 2

$\Delta V = 0$

$\rightarrow a = 0\ \mathrm{ms^{-2}}$; $\Sigma F_x = 0\ \mathrm{N}$

What power is required to pull a 5.0 kg block at a steady speed of 1.25 m/s? The coefficient of friction is 0.30.





$\Sigma F_y = 0 = N - W$

$N = W = mg$

$\Sigma F_x = 0 = F_{ext} - F_f$

$F_{ext} = F_f$

$= \mu_k N$

$F_{ext} = \mu_k mg$

$P = F_{ext} \cdot v \Leftarrow$ instantaneous power

$P = \mu mg v$

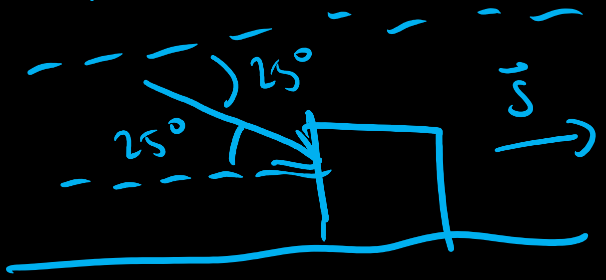
$P = (0.3)(5)(9.81)(1.25)$

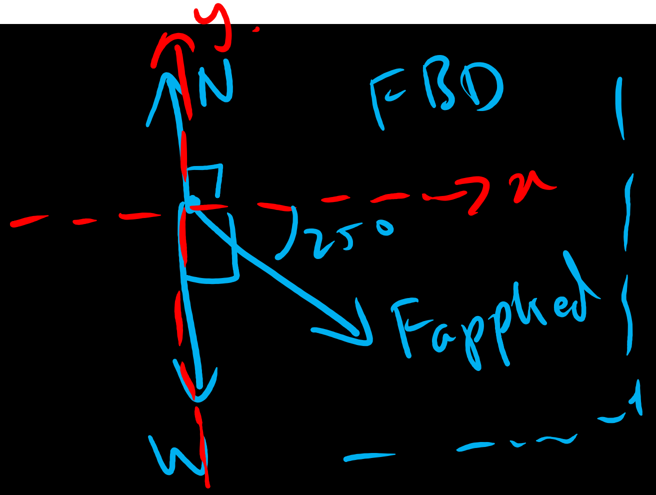
$P = 18.4\ \mathrm{W}$ ※

1. A block of mass 2.50 kg is pushed 2.20 m along a frictionless horizontal table by a constant 16.0 N force directed 25^0 below the horizontal. Determine the work done on the block by

   a) the applied force
   b) the normal force exerted by the table , 0
   c) the gravitational force , 0
   d) Determine the total work on the block

NOT FBD.





$\cos(90)$?

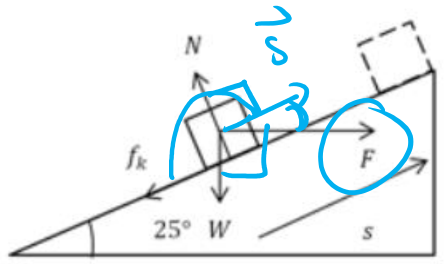
$W_N = N \cdot s$
$= N s \cos 90$
$= 0$

$W_{app} = F \cdot s$
$= (F_{applied})(s)\cos(25^\circ)$

$W_g = W s \cos 90$
$= 0$

2. A box of mass 20 kg moves up a rough plane which is inclined to the horizontal at 25.0^0. It is pulled by a horizontal force F of magnitude 250 N. The coefficient of kinetic friction between the box and the plane is 0.300.

If the box travels 3.80 m along the plane, determine;



a) the work done on the box by the force F
b) the work done on the box by the gravitational force
c) the work done on the box by the reaction force
d) the work done on the box by the frictional force
e) The total work done on the box

a)
$$W_F = F \cdot s$$
$$= Fs\cos 25$$

b)
$$W_g = F_g \cdot s$$
$$= (F_g)(s)\cos(115)$$

c) $W_N = 0\,N$

d)
$$W_{F_f} = F_f \cdot s$$
$$= -F_f s$$

$$W_T = F_s \cos 25 - F_f s.$$

$$W_T = s\left[F\cos 25 - F_f\right] - W_g$$

24 August 2021
10am session

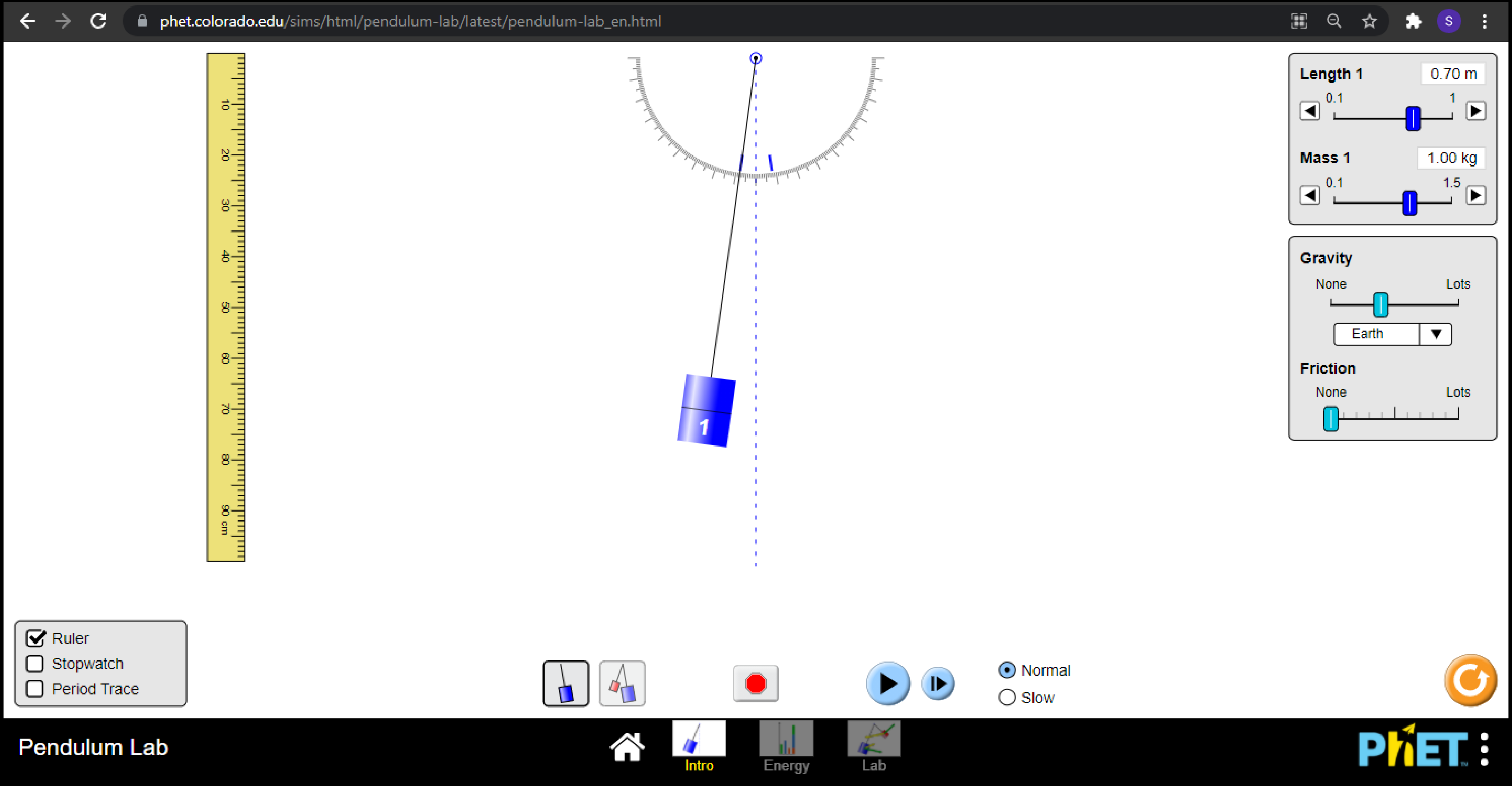
Lab session

Experiment: Simple Harmonic Motion.

Tasks:
1. Complete the prelabs before Thursday.
2. Run the experiment (simulation according to the link given – QR Code)
3. Make sure you take a screenshot before collecting data. This shows your parameters (Gravity set to ‘Earth’, starting angle, frictionless)
4. 2 sets of data (& 4 graphs) are expected (mass-varying & length varying).
5. Full report expected by next Monday.

Pendulum Lab

Screenshot Example



Tutorial session

Sample Problem 1

$E_{ep} = \frac{1}{2}kx^2$

Hooke's Law

spring potential

$\boxed{F = -kx}$

A bow may be regarded mathematically as a spring. The archer stretches this "spring" and then suddenly releases it so that the bowstring pushes against the arrow. Suppose that when the archer stretches the "spring" 0.52 m, he must exert a force of 160 N to hold the arrow in this position. If he now releases the arrow, what will be the speed of the arrow when the "spring" reaches its equilibrium position? The mass of the arrow is 0.020 kg. Pretend that the "spring" is massless.

$E_k = \frac{1}{2}mv^2$

Sample Problem 1

A bow may be regarded mathematically as a spring. The archer stretches this “spring”and then suddenly releases it so that the bowstring pushes against the arrow. Suppose that when the archer stretches the “spring” 0.52 m, he must exert a force of 160 N to hold the arrow in this position. If he now releases the arrow, what will be the speed of the arrow when the “spring” reaches its equilibrium position? The mass of the arrow is 0.020 kg. Pretend that the “spring” is massless.

main

$E_{ep} \rightarrow E_k$

$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$

$x = 0.52m$

$m = 0.02kg$

$v = ?$

$k?$

Supplementary

$F = -kx$

$F = 160N$

$x = 0.52m$

$k = \frac{-F}{x}$

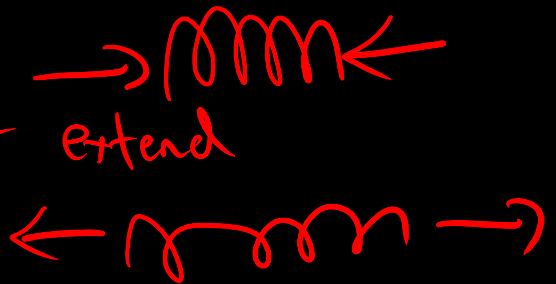
$k = \frac{160}{0.52}$

$k = 307.7\ Nm^{-1}$

reply okay

Okay?

opposite direction $\begin{cases} \text{if compress} \\ \text{if extend} \end{cases}$



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$$\cancel{\tfrac{1}{2}} kx^2 = \cancel{\tfrac{1}{2}} mv^2$$

$$v^2 = \frac{kx^2}{m} = \frac{(307.7)(0.52)^2}{0.02\,kg}$$

$$v^2 = 4159.97\,m^2s^{-2}$$

$$\boxed{v = 64.5\,ms^{-1}}$$

Sample Problem 2

$u=0$ $\quad$ $0s \rightarrow 12s.$

1. A $1.50x10^3$ kg car starts from rest and accelerates uniformly to $18.0ms^{-1}$ in 12.0 s. Assume that air resistance remains constant at 400 N during this time. Find

   a) the average power developed by the engine

   b) the instantaneous power output of the engine at t = 12.0 s, just before the car stops accelerating

1)a) $\cancel{v^2} = v = \cancel{u} + at$

$a = \frac{v}{t}$

$a = \frac{18}{12}$

$\boxed{a = 1.5ms^{-2}}$

$\frac{W}{t} = \frac{F.s}{t}$

$F_{app} \rightarrow$ $\quad$ $\leftarrow F_{air}$

$F_{app} - F_{air} = 2250$

$F_{app} = 2650N$

$F_{net} = ma$

$= (1.5 \times 10^3)(1.5)$

$\simeq 2250.$

$s = \cancel{ut}^{\,0} + \frac{1}{2}at^2$

$s = \frac{1}{2}(1.5)(12)^2$

$= 108m$

Sample Problem 2

1)b) $P = F \cdot v = 2650(18) = 47700\,W$

1. A $1.50x10^3$ kg car starts from rest and accelerates uniformly to $18.0ms^{-1}$ in 12.0 s. Assume that air resistance remains constant at 400 N during this time. Find

   a) the average power developed by the engine

   b) the instantaneous power output of the engine at t = 12.0 s, just before the car stops accelerating

1a)

$P_{ave} = \frac{2650(108)}{12}$

$P_{ave} = 23850\,W$

main

$P = \frac{W}{t} = \frac{F \cdot s}{t}$

supplementary

$v = u + at \longrightarrow a$

$F_{applied} - F_{air} = ma \longrightarrow F$

$s = ut + \frac{1}{2}at^2 \longrightarrow s.$

2, 3, 4, 5 $\Leftarrow$ Linear dynamics.

6 $\Leftarrow$ starts of rotational dynamics.

25th August 2021

Unit Conversion & ~~Angular~~ to ~~rotational~~ velocity

$$1\,\text{rev} = \boxed{2\pi\,\text{rad} = 360^\circ}$$

$$2.\ \text{rad} \rightarrow\ ^\circ$$

$$\left(2\pi\,\text{rad} = 360^\circ\right)\frac{1}{2\pi}$$

$$\left(1\,\text{rad} = \left(\frac{360}{2\pi}\right)^\circ\right)3.$$

$$3\,\text{rad} = \left(\frac{3\times 360}{2\pi}\right)^\circ$$

Linear

angular

$$\Rightarrow \frac{d}{dt}(s) = r\frac{d\theta}{dt}$$

$$\vec{v} = r\,\omega$$

angular velocity

$\vec{v}$	ms^{-1}
r	m
ω	$rad\,s^{-1}$

$$\boxed{s = r\,\theta}$$

radians.

Sample Question 1

$d = 0.5\,m$ $\quad$ $3500\ \boxed{rev/min}$

The drum of a spin drier with an internal diameter of 0.50 m rotates at a constant 3500 revolutions per minute. Find the instantaneous angular speed ω of the drum in units of rad s^{-1}

$1\,rev = 2\pi\ rad = 360°$

$(1\,rev = 2\pi\ rad) \times 3500.$

$3500\ rev = 2 \times 3500 \times \pi\ rad$

$= 7000\pi\ rad$

$1\,min = 60\,s.$

$\dfrac{3500\ rev}{1\,min} = \dfrac{7000\pi\ rad}{60\,s}$

$= \dfrac{7000}{60}\pi\ rad\,s^{-1}$

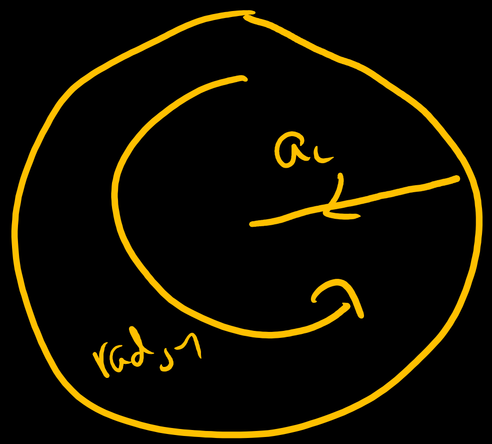
$= \dfrac{350}{3}\pi\ rad\,s^{-1} \approx 116.67\pi\ rad\,s^{-1}$

Circular Motion Models

$a_c = \frac{v^2}{r}$

Centripetal force

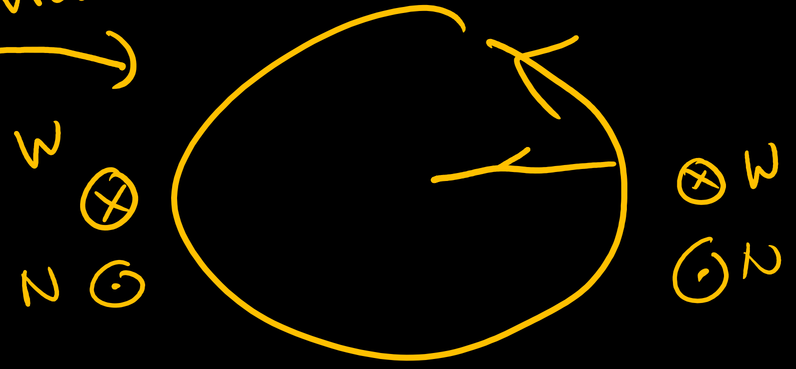
$F_c = ma_c$



horizontal → top view

vertical

conical pendulum



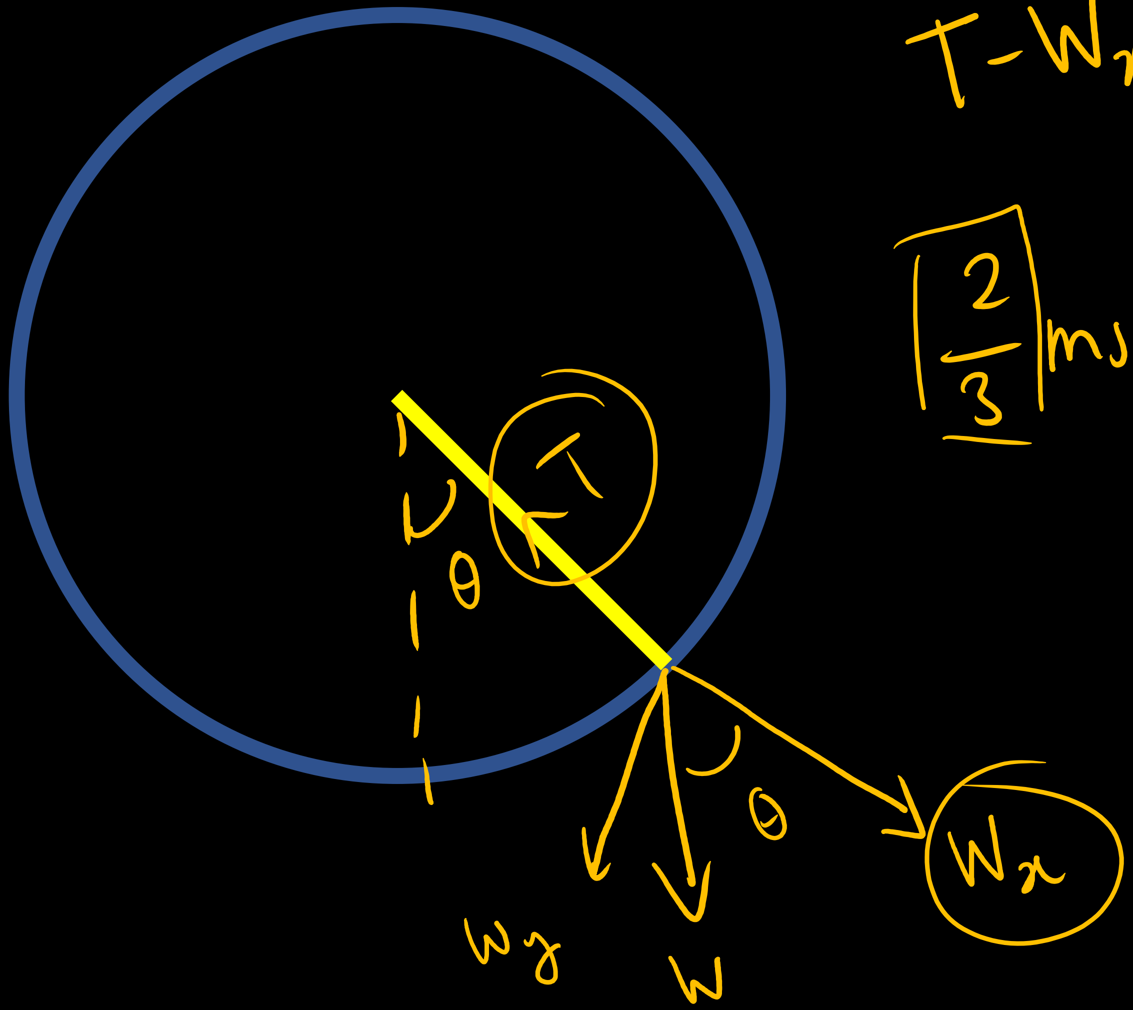
Circular Motion Models

$$T - W_x = F_{net} = F_c = ma_c = \frac{mv^2}{r}$$

$$\boxed{\frac{2}{3}}\, ms^{-1}\ \boxed{\simeq}\ 0.67\ ms^{-1}$$

$0.6666666666\ldots7$

0.67



$\cancel{\pi = 3.14}$

$\pi \simeq 3.14$

Sample Question 2

$\cancel{150}\, m_b$ ①

$1\text{ rev} = 2\pi \text{ rad}$

$2\text{ rev} = 2\pi(2)\text{ rad}$

Acceleration of a revolving ball. A 150 g ball at the end of a string is revolving uniformly in a horizontal circle of radius 0.60 m. The ball makes 2 revolution in a second. What is its centripetal acceleration?

r ②

$2\text{ rev s}^{-1} = \omega$ ③

$$\boxed{a_c = \frac{v^2}{r}}$$

$v = r\omega \Rightarrow v^2 = r^2\omega^2$

linear angular

$$a_c = \frac{r^{\cancel{2}}\omega^2}{\cancel{r}}$$

$$a_c = r\omega^2$$

$2\text{ rev s}^{-1} = 4\pi \text{ rad s}^{-1}$

$$a_c = (0.6\text{m})(4\pi)^2$$

$$= 0.6(16\pi^2)$$

$$= (0.6 \times 16)\pi^2 \; \cancel{\text{rad s}^{-1}}\text{ ms}^{-2}$$

$$a_c = 9.6\pi^2 \text{ ms}^{-2} \simeq 94.75 \text{ ms}^{-2}$$

Thank you!

26hb August 2021

Exam Answering Strategy

K1 ← konsep

G1 ← gantian

JU1 ← Jawapan dgn unit

$F = \boxed{400}\,\boxed{N}$

$a = 2$

$b = 3$

$c = ab$

$= 2(3)$

$= 6$

Definitions

$\boxed{\text{Laws}}$ Konsep

$\boxed{P_{final} = P_{initial}}$ ⇐ $\boxed{1}$

Exam Answering Strategy

$$u_y = u \sin \theta$$

$$S_y = u_y t + \frac{1}{2} a t^2$$

$$a = -g = -9.81$$

$$\theta = 30^\circ$$

$$u = 15$$

Good

$$u_y = u \sin \theta$$

$$= 15 \sin 30^\circ$$

$$\boxed{u_y = 7.5\,ms^{-1}} \quad (1)$$

$$-g = -9.81\,ms^{-2}$$

$$S_y = 7.5(t) - \frac{9.81}{2}(t^2)$$

Bad

$$u_y = u \sin \theta$$

$$a = -g = -9.81$$

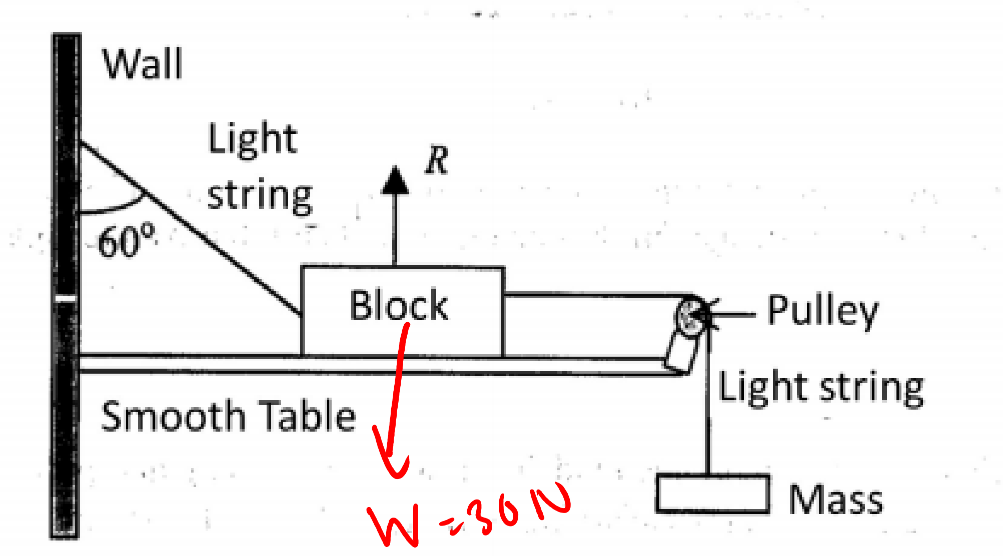
$$S_y = (u \sin \theta) t - \frac{1}{2} g t^2$$

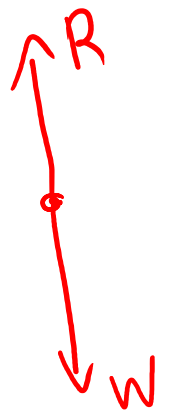
$$= (15 \sin 30) t - \frac{1}{2}(9.81) t^2$$

(1)

Past Year

1. **(PSPM 00/01)**



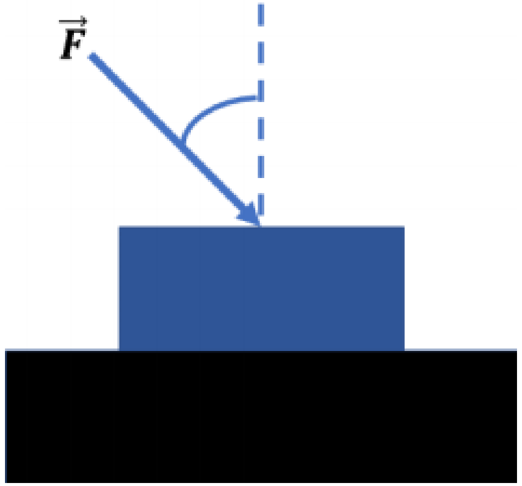


(a) The diagram above shows a pulley system with weighted blocks attached by light strings. If the weight of the block is $30N$, calculate the magnitude of the reaction force, R. $[R = 30N]$

Past Year

7. (PSPM 12/13)

(a) A 0.5 kg box is initially at rest on a smooth horizontal surface. It is acted upon by a horizontal force for a distance of 3 m. If the final speed of the box is $5ms^{-1}$, calculate the magnitude of the force. [**Ans:** $F = 2.08N$]



(b) The figure above shows a $2.0kg$ block is being pushed along a rough surface by a force $F = 30N$ at an angle 60^o from the normal.

i. Sketch a free body diagram for the block. Use common symbol for each force.

ii. If the block moves at constant acceleration $0.5ms^{-2}$, calculate the coefficient of friction. [$\mu = 0.72$]

Past Year

A 0.5 kg box is initially at rest on a smooth horizontal surface. It is acted upon by a horizontal force for a distance of 3 m. If the final speed of the box is $5ms^{-1}$, calculate the magnitude of the force. [**Ans:** $F = 2.08N$]

$S = 3m$

$u = 0ms^{-1}$

$v = 5ms^{-1}$

$F = ma$

0.5

$v^2 = u^2 + 2as$

$5^2 = 2a(3)$

$\frac{25}{6} = a$

$a = \frac{25}{6} ms^{-2}$

$F = 0.5kg\left(\frac{25}{6} ms^{-2}\right)$

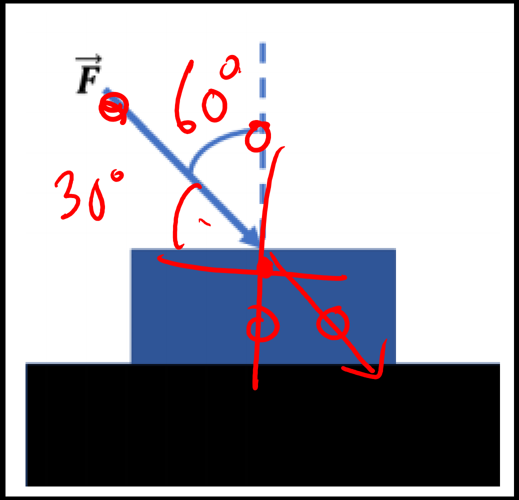
$\boxed{F = 2.083N}$

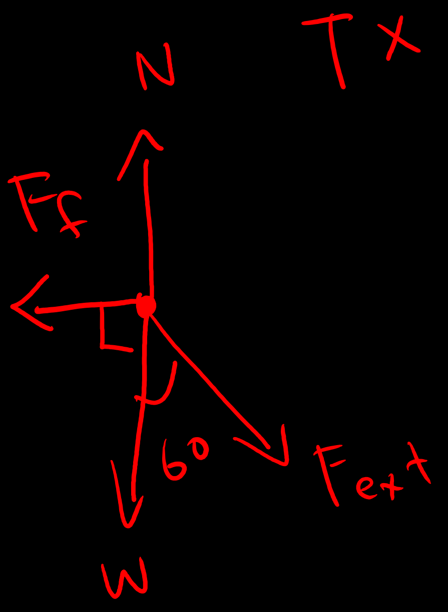
Past Year

(b) The figure above shows a 2.0kg block is being pushed along a rough surface by a force $F = 30N$ at an angle 60^o from the normal.

i. Sketch a free body diagram for the block. Use common symbol for each force.

ii. If the block moves at constant acceleration $0.5ms^{-2}$, calculate the coefficient of friction. [$\mu = 0.72$]





N : normal force

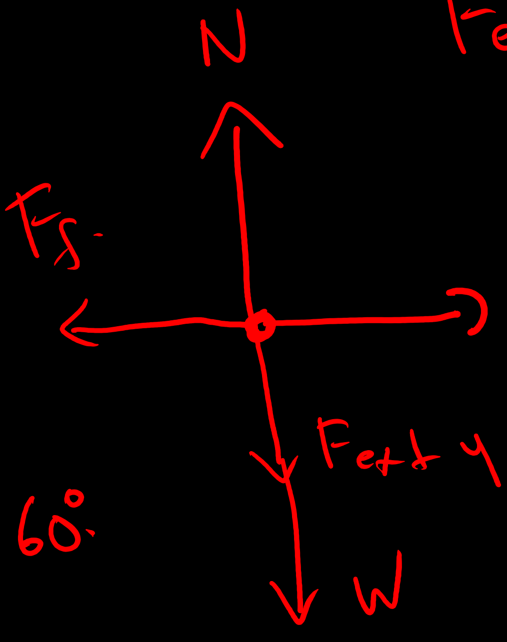
Fext : applied force

W : weight

Ff : frictional force

$\Rightarrow$

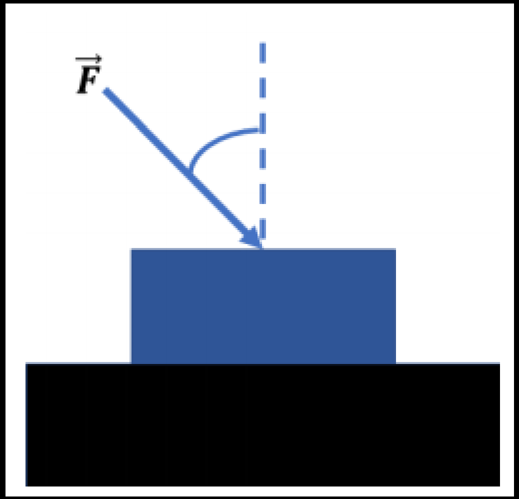
$F_{ext\,y} = F_{ext} \cos 60^o$



$F_{ext\,x} = F_{ext} \sin 60^o$

Past Year

$$N = F_{ext-y} + W \; ; \; F_{ext\,y} = 30 \cos 60$$
$$= 15N$$



(b) The figure above shows a 2.0kg block is being pushed along a rough surface by a force $F = 30N$ at an angle 60^o from the normal.

i. Sketch a free body diagram for the block. Use common symbol for each force.

ii. If the block moves at constant acceleration $0.5ms^{-2}$, calculate the coefficient of friction. [$\mu =$ 0.72]

$$\sum F_y = 0$$

$$\sum F_x = m a_x \quad (1)$$

$$\sum F_x = F_{ext\,x} - F_f$$

$$F_{ext\,x} = 30 \sin 60$$
$$= 25.98N$$

$$F_f = \mu N$$

$$m a_x = \cancel{F} \; 25.98 - \mu N$$

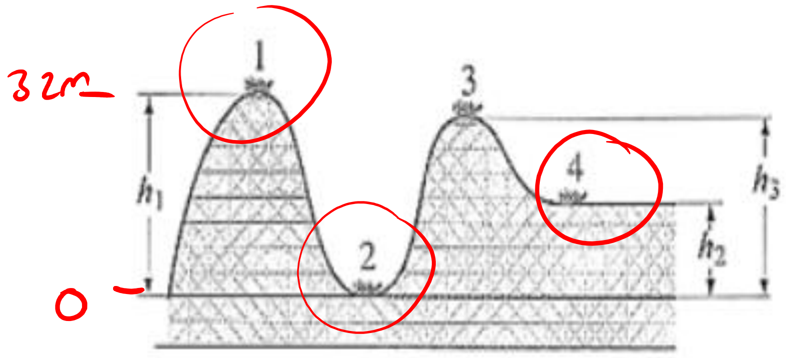
$$2(0.5) = 25.98 - \mu(15 + 2(9.81))$$

$$1 = 25.98 - \mu(34.62)$$

$$\mu = \frac{25.98 - 1}{34.62} \approx \boxed{0.722}$$

Past Year

1. A roller-coaster car shown in the figure is pulled up to point 1 where it is released from rest.



Assuming no friction, calculate the speed at points 2, 3 and 4.
Given that $h_1 = 32m$, $h_2 = 14m$ and $h_3 = 26m$

① max E_{gp}

$E_k = 0$

② $E_{gp} \rightarrow E_k$

$\cancel{m}gh_1 = \frac{1}{2}\cancel{m}v_2^2$

$v_2^2 = 2gh$

$v_2 = \sqrt{2gh}$

$v_2 = (2 \times 9.81 \times 32)^{1/2}$

$V_2 = 25.057\ ms^{-1}$

③ $E_{gp}^{i} \rightarrow E_k^{f} + E_{gp}$

$\cancel{m}gh_1 = \frac{1}{2}\cancel{m}v_3^2 + \cancel{m}gh_3$

$2(gh_1 - gh_3) = v_3^2$

$V_3 = \sqrt{2}(9.81)^{1/2}(h_1 - h_3)^{1/2}$

32 26

$V_3 = 10.85\ ms^{-1}$

④ $E_{gp}^{i} \rightarrow E_k + E_{gp}^{f}$

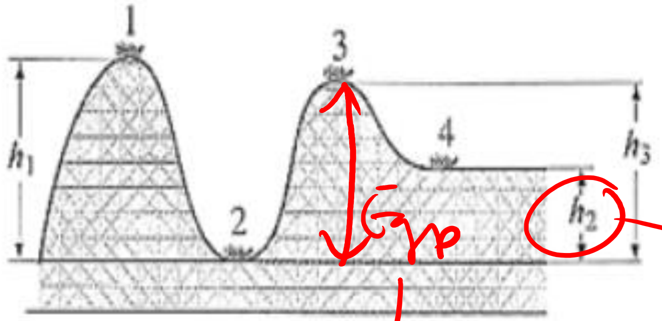
$\cancel{m}gh_1 = \frac{1}{2}\cancel{m}v_4^2 + \cancel{m}gh_2$

$V_4 = [2g(h_1 - h_2)]^{1/2}$

$V_4 = 18.77\ ms^{-1}$ #

Past Year

1. A roller-coaster car shown in the figure is pulled up to point 1 where it is released from rest.



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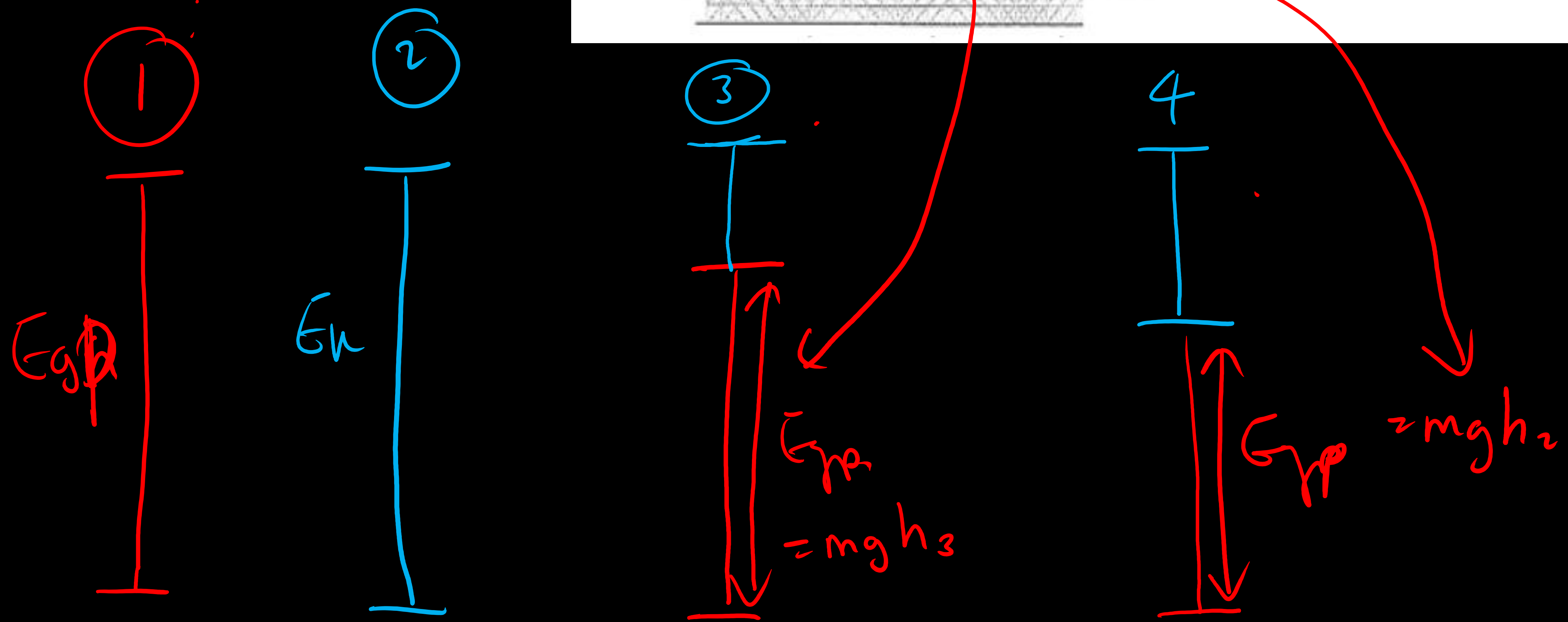


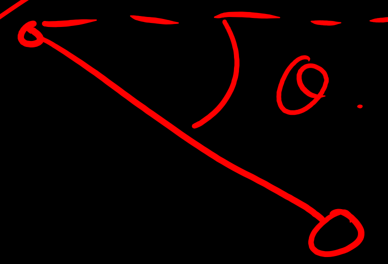
Past Year

Horizontal Circular motion

2. A ball of mass 0.60 kg attached to the end of a string and swings horizontally over a circle of radius 0.60 m. The ball swings at constant speed of $3.3 ms^{-1}$. Determine the centripetal acceleration.

v

$$a_c = \frac{v^2}{r} = \frac{(3.3)^2}{0.6} = 18.15 ms^{-2}$$



$\boxed{\text{Conical : } \theta \text{ from the horizontal}}$

Thank you!

Chapter 6: Circular Motion

UCM
VCM
CP

$a_c = \frac{v^2}{r}$

$F_c = \frac{mv^2}{r} = ma_c$

27 August 2021

Sample Problem 1

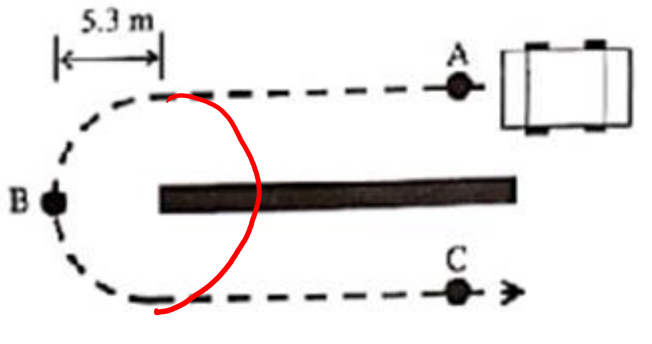


FIGURE 6
RAJAH 6

$r = 5.3\,m$

$m = 950\,kg$

$v = 15.3\,ms^{-1}$

a)

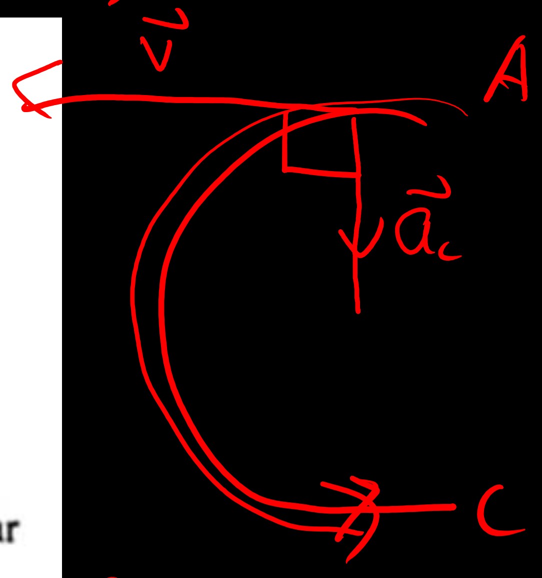


FIGURE 6 shows the top view of a U turn at a road divider. The radius of the circular curve is 5.3 m. A 950 kg car maintains a speed of 15.3 m s^{-1} along points A to C.

(a) Copy the path and indicate the directions of velocity and acceleration of the car at point B.

(b) Calculate the centripetal acceleration of the car at point B.

(c) Calculate the centripetal force on the car at point B.

(d) Determine the magnitude and the direction of the frictional force on the car at point B.

b)

$a_c = \frac{v^2}{r}$

$= \frac{(15.3)^2}{5.3} \approx 44.17\,ms^{-2}$

Sample Problem 1

c)

$F_c = m a_c$

$= 950(44.17)$

$= 41961.5 N$

d) F_f : Same direction & magnitude as F_c

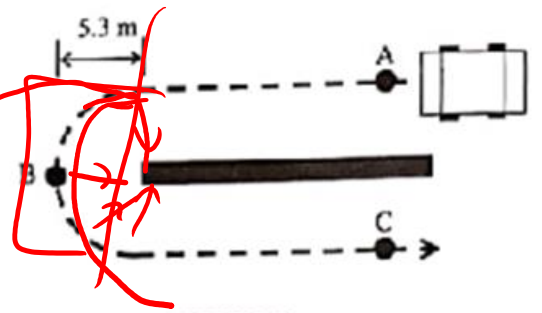


FIGURE 6
RAJAH 6

FIGURE 6 shows the top view of a U turn at a road divider. The radius of the circular curve is 5.3 m. A 950 kg car maintains a speed of 15.3 m s^{-1} along points A to C.

(a) Copy the path and indicate the directions of velocity and acceleration of the car at point B.

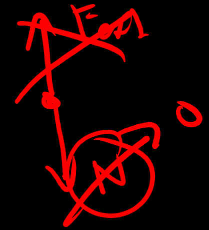
(b) Calculate the centripetal acceleration of the car at point B.

(c) Calculate the centripetal force on the car at point B.

(d) Determine the magnitude and the direction of the frictional force on the car at point B.

Sample Problem 2

$F_f = 0$



F_c $\sum F_x$ $\sum F_y$

6. In a loop-the-loop ride a car goes around a vertical, circular loop at a constant speed. The car has a mass m = 500 kg and moves with speed $v = 20ms^{-1}$. The loop-the-loop has a radius of r = 20 m.

   d) What is the minimum speed of the car so that it stays in contact with the track at the top of the loop?

$m = 500$ kg

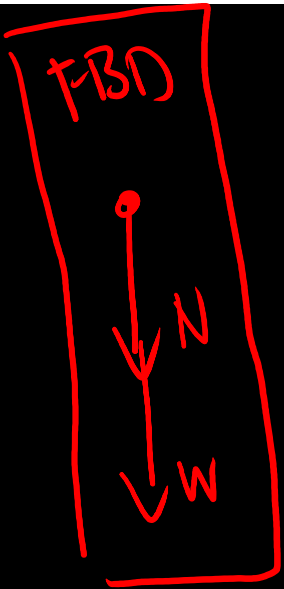
$20\ ms^{-1} = v$

$r = 20$ m

V_{min}

side view

Sketch



$F_c = \cancel{N}^0 + W$

$\frac{\cancel{m}v^2}{r} = \cancel{m}g$

$\boxed{\frac{v^2}{r} = g}$

$\boxed{v = \sqrt{gr}}$

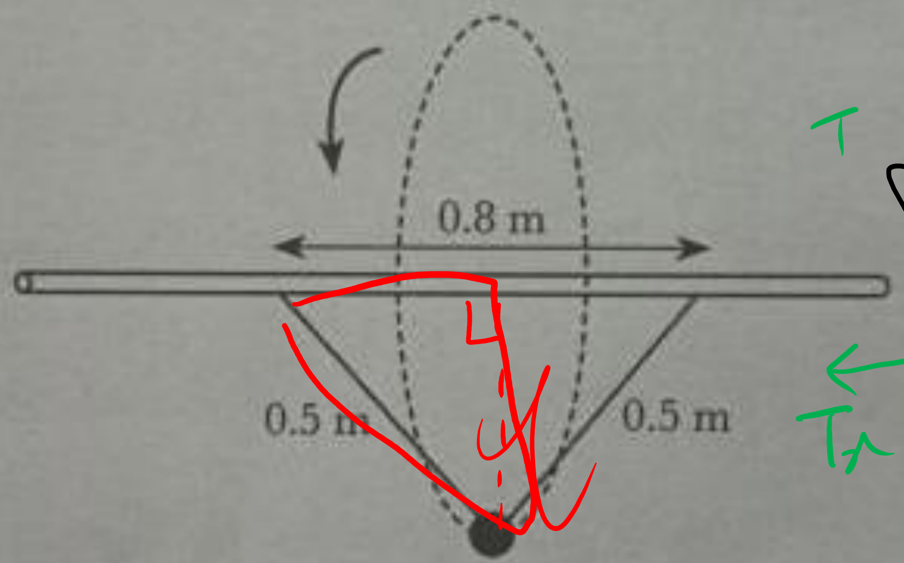
$v = 14.01\ ms^{-1}$

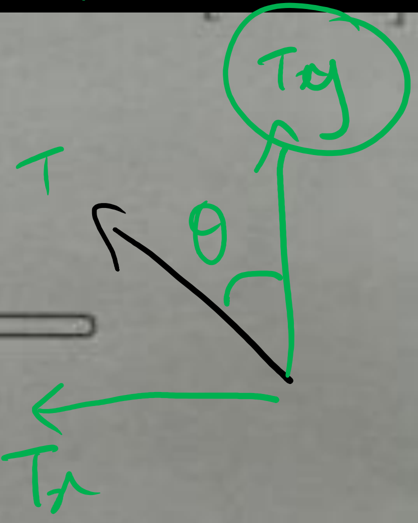
Sample Problem 3

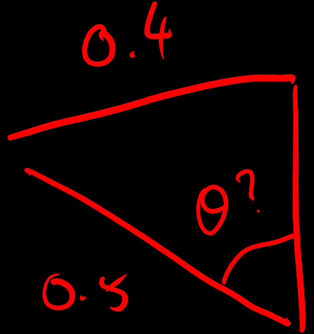
$T_y = T\cos\theta$

$V = 10\ ms^{-1}$

(c)







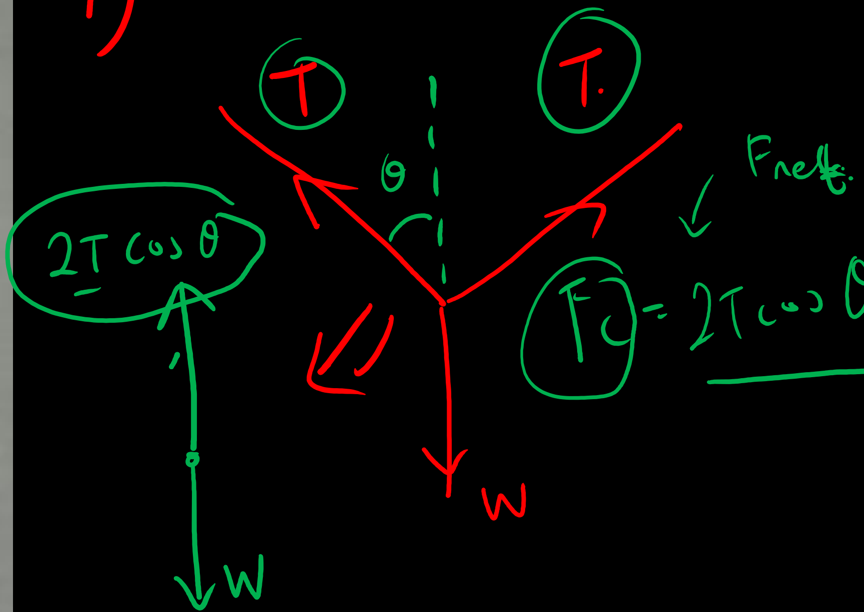
$\theta \approx 53.13°$

The figure above shows a 200 g ball attached to a horizontal rod by two strings, each of length 0.5 m. The ball is whirled with speed 10.0 m s^{-1} around the rod axis. Determine the tension in the strings when the ball is at

(i) the lowest point,

(ii) the highest point. [10 marks]

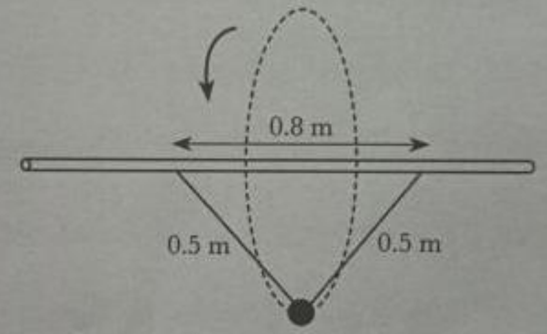
i)



$F_c = 2T\cos\theta - W$

Sample Problem 3

(c)



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(i) the lowest point,

(ii) the highest point.

[10 marks]

Lowest point

$a_c \uparrow \quad \uparrow 2T\cos\theta$

$\downarrow W$

$$F_c = 2T\cos\theta - W$$

If $2T\cos\theta = W_g$

then $\boxed{F_c = 0} \Rightarrow$ no circular motion.

$$\frac{\left(\frac{mv^2}{r} + mg\right)}{2\cos\theta} = T$$

$$\frac{0.2\left(\frac{10^2}{0.3} + 9.81\right)}{2\cos(53.13)} = T$$

$$T \approx 57.19\,N \quad \#$$

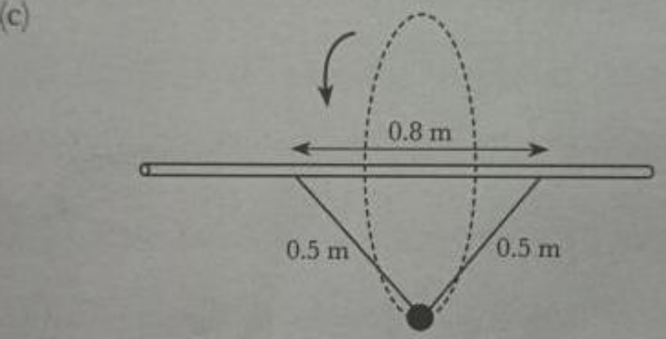
Chapter 4

$F_1 \longleftarrow \circ \longrightarrow F_2$, $\vec{a}$

$$\sum F_x = F_2 - F_1$$

Sample Problem 3

(c)



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(i) the lowest point,

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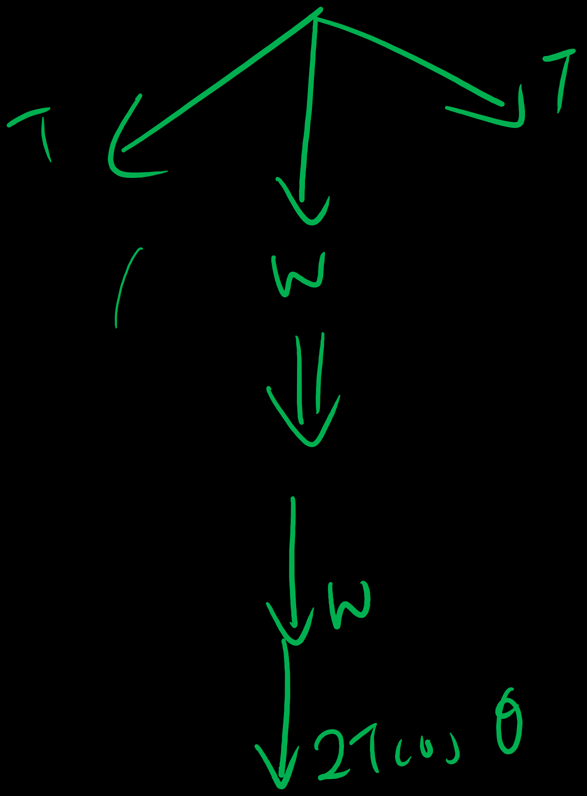
[10 marks]



$$F_c = W + 2T\cos\theta$$

$$T = \frac{F_c - W}{2\cos\theta}$$

$$T = \frac{\frac{mv^2}{r} - mg}{2\cos\theta}$$

$$T = \frac{0.2\left(\frac{10^2}{\cancel{0.3}\ 0.3} - 9.81\right)}{2\cos 53.13}$$

~~$T = 31.7$ N~~

$T = \cancel{2}.53.920$ N

Thank you !

30 August 2021

4. As shown in FIGURE 5, a 1.34 kg ball is connected by means of two massless strings to a vertical, rotating rod. the strings are tied to the rod and stretched. The tension in the upper string is 35 N.

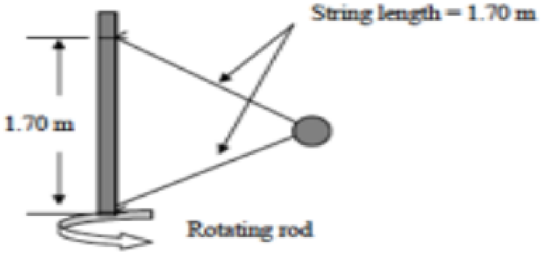
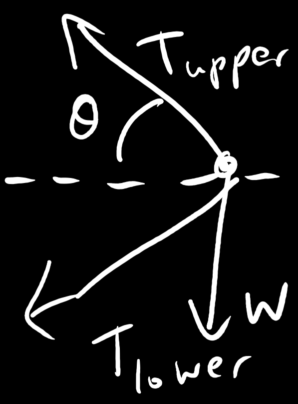


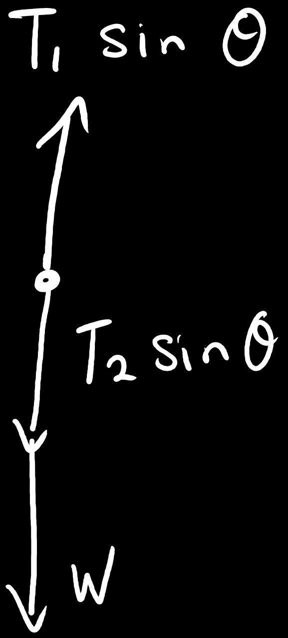
FIGURE 5

a) Draw free body diagram
b) Calculate tension in the lower string
c) Calculate net force on the ball
d) Calculate the speed of the ball

4a)



b)



$\sum F_y = 0$

$T_1 \sin\theta = T_2 \sin\theta + W$

$T_2 = \dfrac{T_1 \sin\theta - W}{\sin\theta}$

$T_2 = 35 - \dfrac{1.34(9.81)}{0.5}$

$\underline{T_2 = 8.7092N}$

c)

$F_{net} = F_{x\,net}$

$= T_1 \cos\theta + T_2 \cos\theta$

$= 0.866[35 + 8.71]$

$\approx 37.853N$

#

4. As shown in FIGURE 5, a 1.34 kg ball is connected by means of two massless strings to a vertical, rotating rod. the strings are tied to the rod and stretched. The tension in the upper string is 35 N.

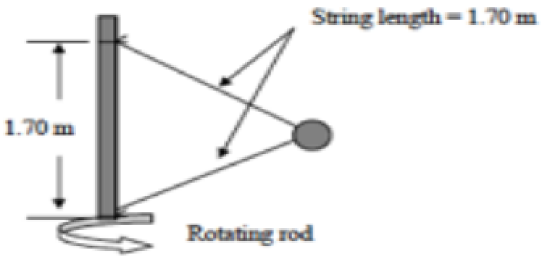


FIGURE 5

a) Draw free body diagram
b) Calculate tension in the lower string
c) Calculate net force on the ball
d) Calculate the speed of the ball

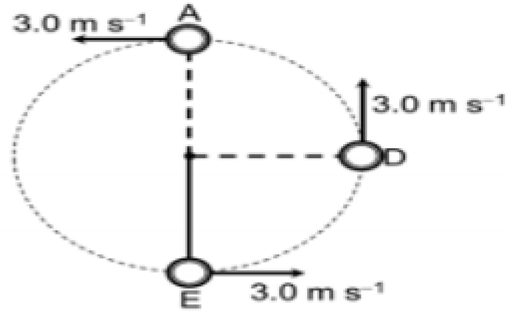
$F_{net} = F_c = 37.85N$

$\frac{mv^2}{r} = 37.85$

$v^2 = \frac{37.85(1.47)}{1.34}$

$V = 6.443758 ms^{-1}$

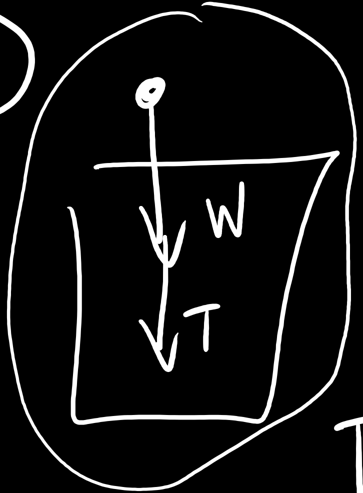
5. A sphere of mass 5.0 kg is tied to a string. It moves in a vertical circle of radius 0.55 m at a constant speed of $3.0ms^{-1}$ as shown in the figure.



Determine the tension of the string at points A, D and E.

$V = 3ms^{-1}$

A



$F_c = \sum F_y$

$\frac{mv^2}{r} = W + T$

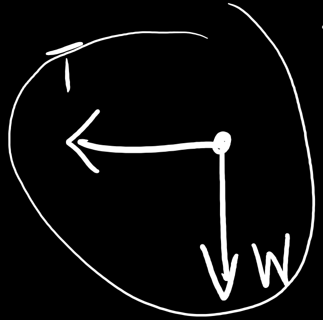
$T = \frac{mv^2}{r} - W$

$T = m\left[\frac{v^2}{r} - g\right]$

$T = 5\left[\frac{9}{0.55} - 9.81\right]$

$T \approx 32.77N$

D

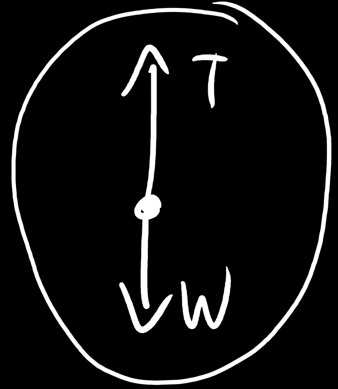


$F_c = T$

$T = \frac{mv^2}{r}$

$T = \frac{5(9)}{0.55} \approx 81.81N$

E



$F_c = T - W$

$T = F_c + W$

$= \frac{mv^2}{r} + mg$

$T = m\left[\frac{v^2}{r} + g\right]$

$T = 5\left[\frac{9}{0.55} + 9.81\right]$

$T \approx 130.868181$ N

accelerating

2. An elevator has mass of $1.50x10^4$ kg and is carrying 15 passengers through a height of 20 m from the ground. If the time taken to lift the elevator to that height is 55 s. Calculate the average power required by the motor if no energy is lost. (Given that the average mass per passenger is 55 kg).

$m = 1.5(10^4)$ kg

$s = 20$ m

$t = 55$ s

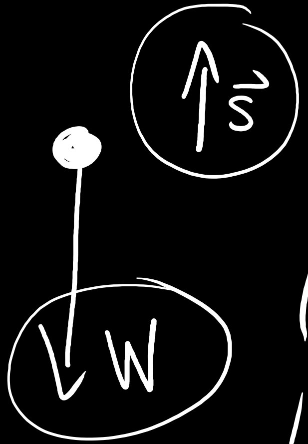
$$P = \frac{W}{t} = \frac{F \cdot s}{t}$$

$$P = \frac{mg \cdot s}{t}$$

$$P = -\frac{mgs}{t}$$

$m_p = 55(15)$

$= 825$ kg



$$P = -\frac{[1.5(10^4)+825][9.81][20m]}{55s}$$

$$P_{ave} = -5.645(10^4)W.$$

Thank you!

1st September 2021

Time allocation:
1h (Lecture) + 4h (Tutorial)
Learning Outcomes:

1. State and use Newton's Law of Gravitation, $F = G\frac{Mm}{r^2}$
2. State and use gravitational field strength, $a_g = G\frac{M}{r^2}$
3. Define and use gravitational potential energy, $U = -G\frac{Mm}{r}$
4. Derive and use escape velocity equation, $v_{esc}\sqrt{\frac{2GM}{R}} = \sqrt{2gR}$
5. Derive and use satellite motion equation:
   - Velocity, $v = \sqrt{\frac{GM}{r}}$
   - Period, $T = 2\pi\sqrt{\frac{r^3}{GM}}$

$F \propto -x$

$\Downarrow$

$F = -kx$

elastic constant

$F \propto \frac{m_1 m_2}{r^2}$

$\Downarrow$

$F_g = \frac{G m_1 m_2}{r^2}$ — (1)

gravitational constant

$F_g = m_1 a_g$ — (2)

$F \propto m_1 m_2$

$F \propto \frac{1}{r^2}$

$\left.\right\} F \propto \frac{m_1 m_2}{r^2}$

$F_g = m_1 \left(\frac{G m_2}{r^2} \right)$

Time allocation:
1h (Lecture) + 4h (Tutorial)
Learning Outcomes:

1. State and use Newton's Law of Gravitation, $F = G\frac{Mm}{r^2}$
2. State and use gravitational field strength, $a_g = G\frac{M}{r^2}$
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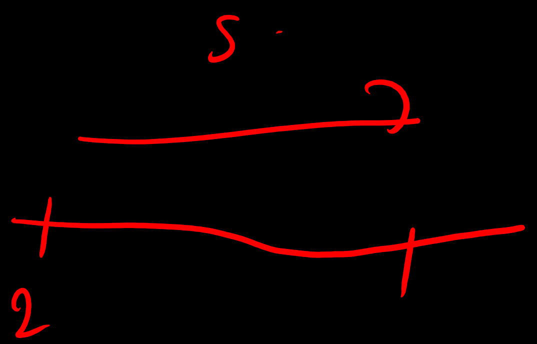


$\Delta W = U$

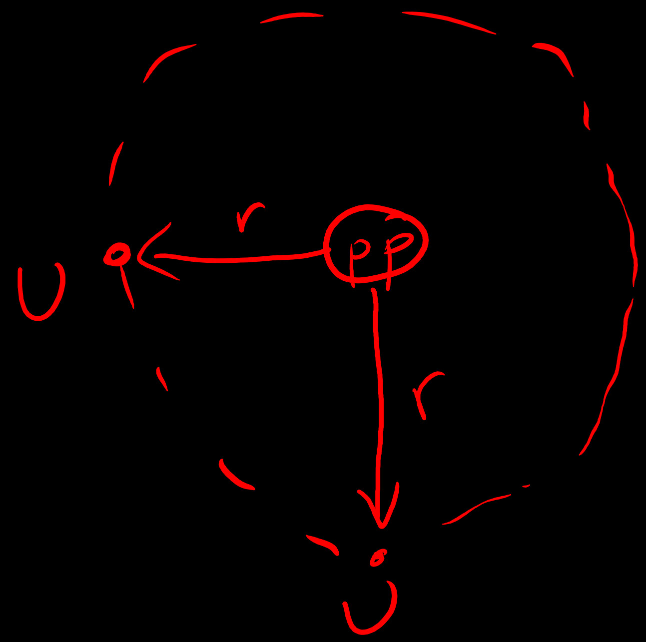
$W = -F \cdot r$

$W = -\frac{Gm_1m_2}{r^{\cancel{2}}}(\cancel{r})$

$W = -\frac{Gm_1m_2}{r}$

$\Downarrow$

$U = -\frac{Gm_1m_2}{r}$



Time allocation:
1h (Lecture) + 4h (Tutorial)
Learning Outcomes:

1. State and use Newton's Law of Gravitation, $F = G\frac{Mm}{r^2}$
2. State and use gravitational field strength, $a_g = G\frac{M}{r^2}$
3. Define and use gravitational potential energy, $U = -G\frac{Mm}{r}$
4. Derive and use escape velocity equation, $v_{esc} = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}$
5. Derive and use satellite motion equation:
   - Velocity, $v = \sqrt{\frac{GM}{r}}$
   - Period, $T = 2\pi\sqrt{\frac{r^3}{GM}}$

chapter 6.

$E_k = E_p$

$\frac{1}{2}\cancel{m_1}v^2 = \frac{G\cancel{m_1}m_2}{r}$

$\sqrt{v^2} = \sqrt{\frac{2Gm_2}{r}}$

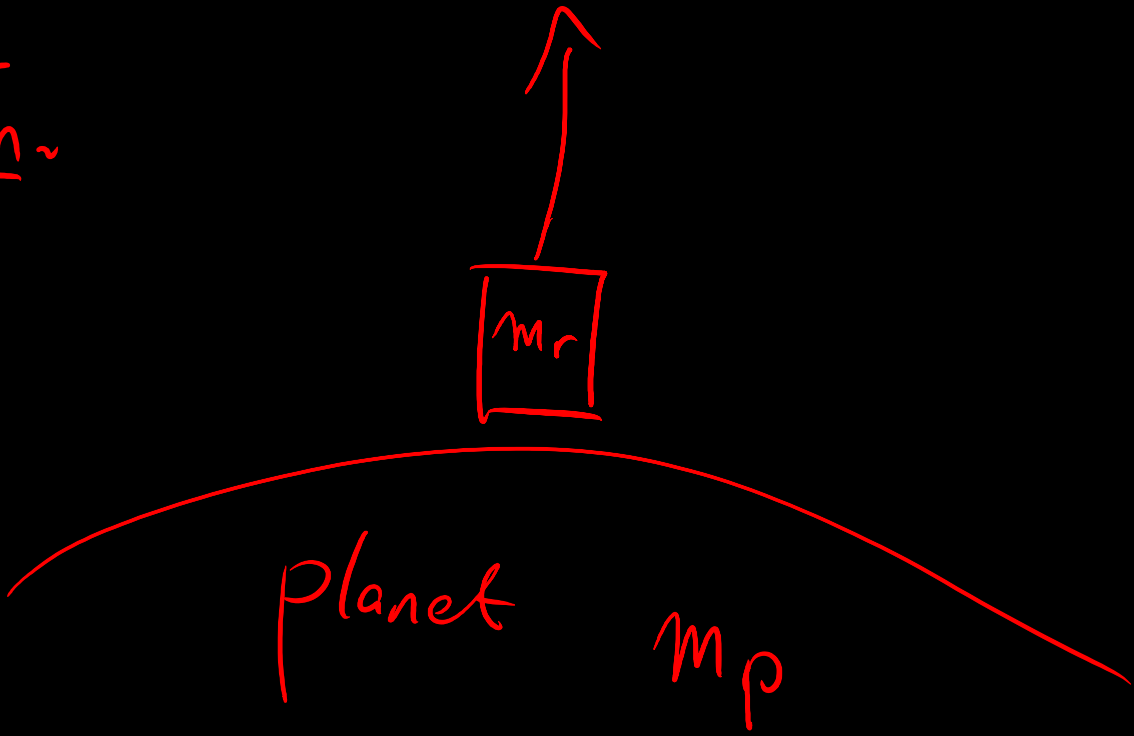
$V = \sqrt{\frac{2Gm_2}{r}}$

$E_{kr} = E_p$

$\boxed{\frac{1}{2}\cancel{m_r}V_r^2} = \frac{G\cancel{m_r}m_p}{r}$

$V_r = \sqrt{\frac{2Gm_p}{r}}$

$V = \cancel{\sqrt{\frac{2Gm_r}{r}}}$ ~~or~~ $\sqrt{\frac{2Gm_p}{r}}$



1. Two spherical objects have masses of 200 kg and 500 kg. Their centers are separated by a distance of 25 m. Find the gravitational attraction between them.
2. Two spherical objects have masses of 1.5 x 10^5 kg and 8.5 x 10^2 kg. Their centers are separated by a distance of 2500 m. Find the gravitational attraction between them.

① $F = \frac{G m_1 m_2}{r^2} = \frac{(6.67 \times 10^{-11})(200)(500)}{25^2}$

1. Two spherical objects have masses of 200 kg and 500 kg. Their centers are separated by a distance of 25 m. Find the gravitational attraction between them.
2. Two spherical objects have masses of 1.5 x 10^5 kg and 8.5 x 10^2 kg. Their centers are separated by a distance of 2500 m. Find the gravitational attraction between them.

(1)

$m_1 = 200\,kg$

$m_2 = 500\,kg$

$r = 25\,m$

$$F = \frac{G m_1 m_2}{r^2}$$

$$= \frac{6.67 \times \boxed{2 \times 5}^{10}}{(25^2)}\left[10^{-11+2+2}\right]$$

$$= \frac{66.7}{25^2}\left[10^{-7}\right]$$

$F \approx 1.0672 \times 10^{-8}\,N$

1. Two spherical objects have masses of 200 kg and 500 kg. Their centers are separated by a distance of 25 m. Find the gravitational attraction between them.
2. Two spherical objects have masses of 1.5×10^5 kg and 8.5×10^2 kg. Their centers are separated by a distance of 2500 m. Find the gravitational attraction between them.

2

$$F = \frac{G m_1 m_2}{r^2} = \frac{6.67 \times 1.5 \times 8.5}{(2500)^2}\left[10^{-11+5+2}\right]$$

$$\boxed{F \approx 1.4 \times 10^{-9}\ \text{N}}$$

$$\frac{7500\left(10^{-2}\right)}{25} \Longrightarrow \frac{75 \times 10^{\boxed{2}} \times 10^{\boxed{-4}}}{25}$$

$$\Downarrow$$

$$\frac{75}{25} = 3 \ \#$$

3. Two spherical objects have masses of 3.1 x 10⁵ kg and 6.5 x 10³ kg. The gravitational attraction between them is 65 N. How far apart are their centers?

m_1 ✓

m_2 ✓

F ✓

G ✓

r?

$$r^2 = \frac{Gm_1m_2}{F}$$

$$r^2 = \underbrace{\frac{6.67 \times 3.1 \times 6.5}{65} \left[10^{-11+5+3}\right]}$$

$$\left(r^2 = 2.0677 \times 10^{-3}\ m^2\right)^{1/2}$$

$$r \approx 0.0455\ m$$

4. Two spherical objects have equal masses and experience a gravitational force of 25 N towards one another. Their centers are 36 cm apart. Determine each of their masses.

$m_1 = m_2 = m$; $F = 25N$; $r = 36 \times 10^{-2}$ m

$F = \frac{Gm^2}{r^2}$

$m^2 = \frac{Fr^2}{G} = \frac{(25)(36)^2}{6.67}$

$\left[10^{-2-2-(-11)}\right]$

m?

$m \approx 220398.984$ kg #

$\boxed{(ab)^2 = a^2 b^2}$

$(36 \times 10^{-2})^2 = 36^2 \times (10^{-2})^2$

Estimate the mass of the Earth if the radius of the Earth is 6378.1 kilometres.

THANK YOU!

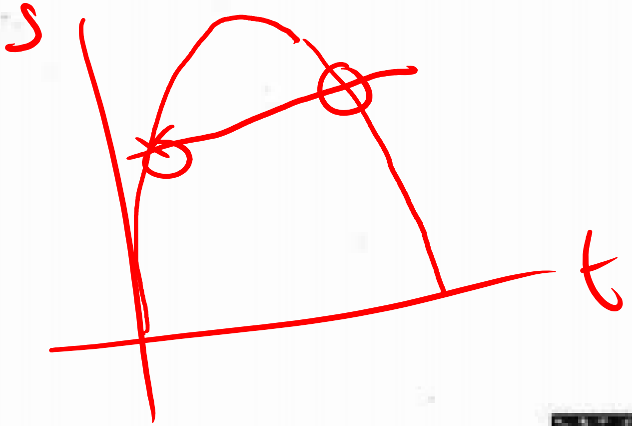
Nasi
Briyani
sedap

2nd September 2021

Problem 1

$u = 600 \text{ ms}^{-1}$

(b)



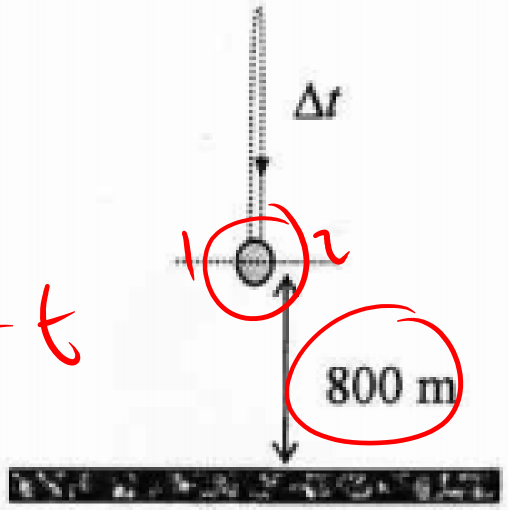


FIGURE 3

A bullet is fired vertically upwards with an initial speed of 600 m s^{-1}. Calculate the time interval, Δt for the bullet to be 800 m above ground as shown in **FIGURE 3**.

[3 *marks*]

Problem 1

A bullet is fired vertically upwards with an initial speed of 600 m s^{-1}. Calculate the time interval, Δt for the bullet to be 800 m above ground as shown in **FIGURE 3**.

[3 *marks*]

$s = 800m$

$a = -9.81$

$u = 600 ms^{-1}$

$\Delta t = t_2 - t_1$

$s = ut + \frac{1}{2}at^2$

$800 = 600t + \frac{1}{2}(-9.81)t^2$

$-4.905\boxed{t^2} + 600\boxed{t} - 800 = 0$

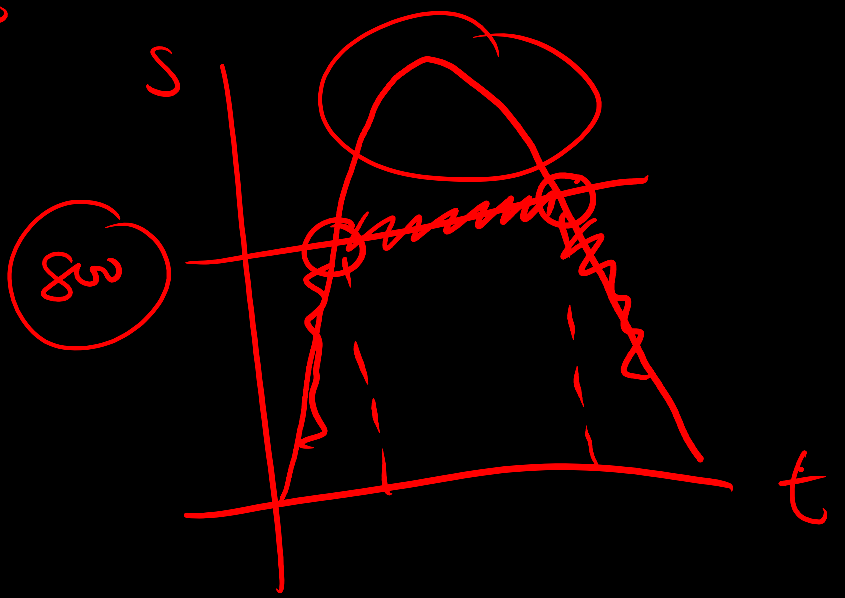
$t_1 = 1.348s$

$t_2 = 120.98s$

$\Delta t = t_2 - t_1$

$= 120.98 - 1.348$

$= 119.63s$



Problem 2

(c) (i) Why is the displacement and velocity in a projectile motion can be analysed separately in the x and y-directions?

(ii) A projectile is launched with a velocity of 45 m s^{-1} at an angle of 60° from the horizontal. Determine the time when the velocity makes an angle 30° with the horizontal for first time.

[5 *marks*]

Cartesian coordinate

$u = 45\ ms^{-1}$

$\theta = 60°$

$\theta = ?\quad t?$

$t(\theta = 30°)$.

$\cancel{s = ut}$

$\cancel{s_x = u_x t = u\cos\theta\, t}$ — (1)

$\cancel{s_y = u_y t = u\sin\theta}$ — (2)

$\cancel{\frac{(2)}{(1)} : \frac{\sin\theta}{\cos\theta} = \tan\theta = \frac{s_y}{s_x}}$

$V = u + at$

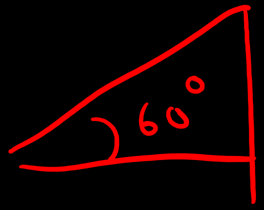
$V_x = u_x = u \cos\theta$

$V_y = u_y - gt$.

$V_y = u\sin\theta - gt$

$V_x = u\cos\theta$

tan



Problem 2

(c) (i) Why is the displacement and velocity in a projectile motion can be analysed separately in the *x* and *y*-directions?

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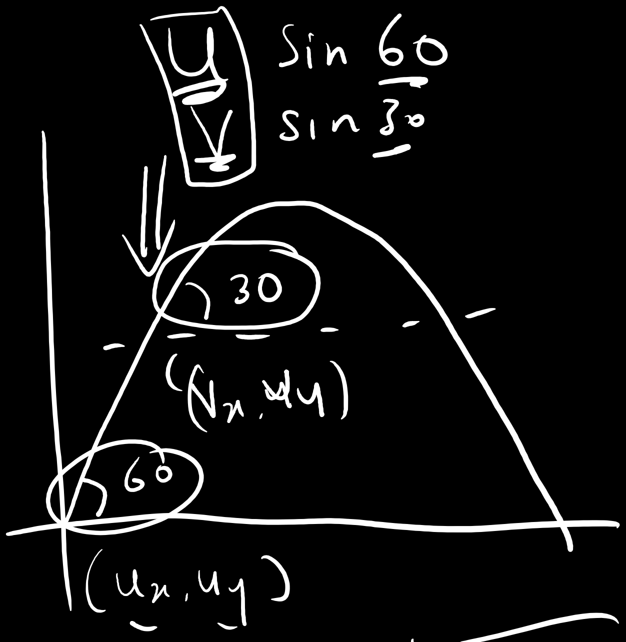
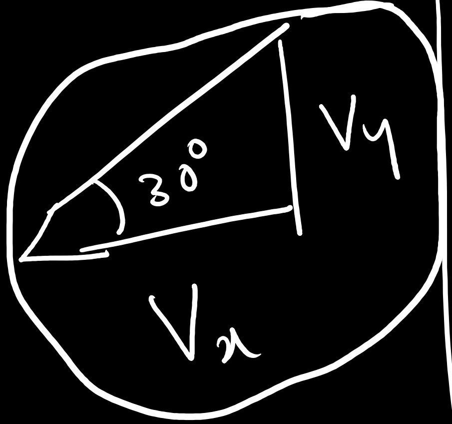
[5 *marks*]





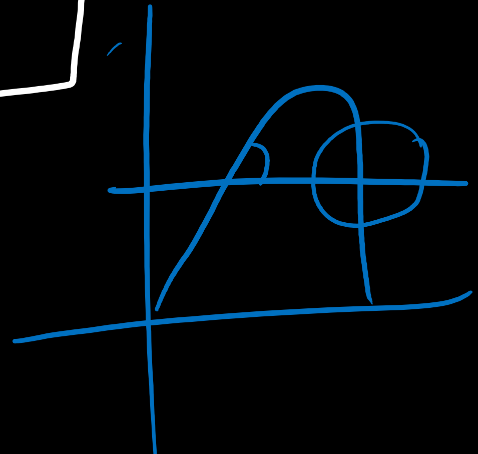
$$\tan 30 = \frac{V_y}{V_x} = \frac{u \sin\theta - gt}{u\cos\theta}$$

$\neq \theta$

$$\tan 30 = \frac{45 \sin 60 - 9.81(t)}{45 \cos 60}$$

$$0.5774 = \frac{38.97 - 9.81t}{22.5}$$

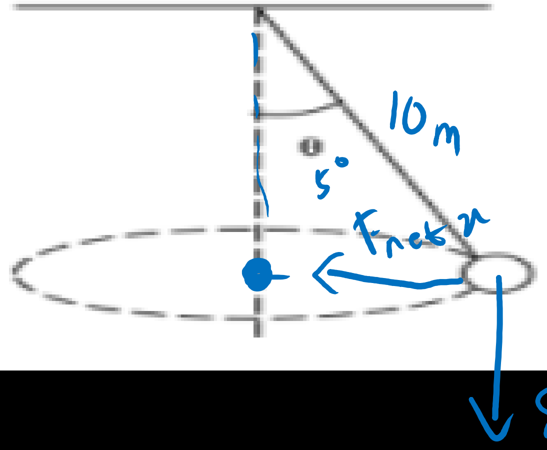
$$t = 2.648\,s$$



Chapter 2 to 4 Submissions

Problem 3

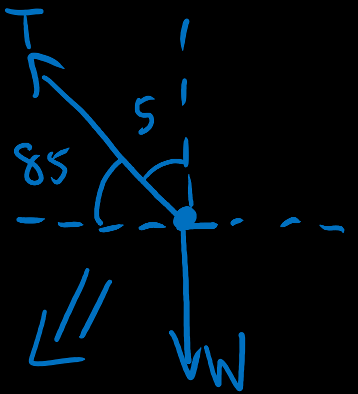
7. Figure shows a conical pendulum with a bob of mass 80.0 kg on a 10.0 m long string making an angle of 5^0 to the vertical.

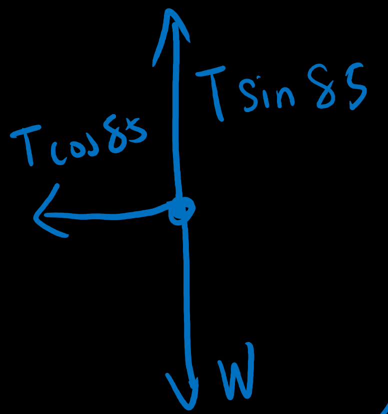


Calculate

a) The tension in the string
b) The speed of the bob
c) The period of the bob
d) The centripetal acceleration of the bob

FBD





a) Consider y-component

$$\sum F_y = 0 = T\sin 85 - W$$

$$T = \frac{W}{\sin 85} = \frac{80(9.81)}{\sin 85} = 787.8\text{N}$$

b) Consider x component

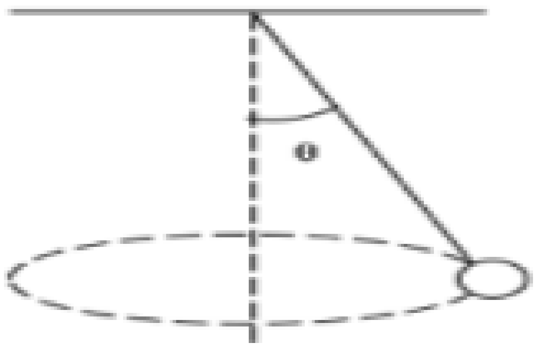
$$\sum F_x = F_c = T\cos 85$$

$$\frac{mv^2}{r} = (787.8)\cos 85$$

$$v^2 = \frac{(787.8)\cos 85\,(10\sin 5)}{80\text{kg}}$$

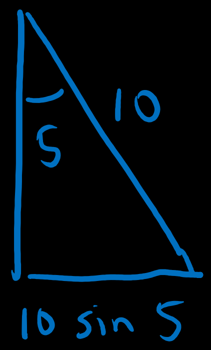
Problem 3

7. Figure shows a conical pendulum with a bob of mass 80.0 kg on a 10.0 m long string making an angle of 5^0 to the vertical.



Calculate

a) The tension in the string
b) The speed of the bob
c) The period of the bob
d) The centripetal acceleration of the bob



$$V^2 = \frac{(787.8)(\cos 85)(10\sin 5)}{80.}$$

$$V = 0.864\ ms^{-1}$$

$$a_c = \frac{v^2}{r} = \frac{(0.864)^2}{10\sin 5^0} = 0.857\ ms^{-2}$$

c) $\omega = \frac{2\pi}{T}$ $\frac{[rad]}{[s]}$

$$V = r\omega = r\left(\frac{2\pi}{T}\right)$$

$$V = \frac{2\pi r}{T} \Rightarrow T = \frac{2\pi r}{v} = \frac{2\pi(10\sin 5)}{0.864}$$

$$\boxed{T = 6.33s.}$$

Thank you!

3rd September 2021

LO5- Satellite motion

Assumption: Satellite motion has a circular path, this simplifies equations.

Referring to the past chapter, we utilize centripetal force and compare it with the gravitational force equation to obtain the equation for satellite velocity:

$$F_{centripetal} = F_{grav}$$

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$v = \sqrt{\frac{GM}{r}}$$

The period of the satellite motion can be derived by utilizing

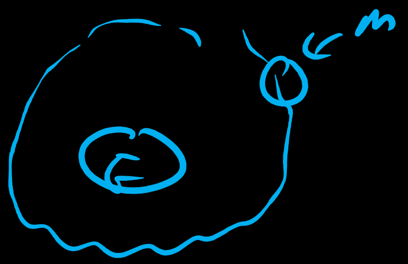
$$v = \frac{2\pi r}{T}$$

to show that period of satellite is

$$T = 2\pi\sqrt{\frac{r^3}{GM}}$$

$$\frac{\cancel{m_m} v^2}{r} = \frac{G M_E \cancel{m_m}}{r^2}$$

$$V = \sqrt{\frac{G M_E}{r^2}}$$



$$\boxed{V = \sqrt{\frac{G M_s}{r^2}}}$$

Sample Problem 1

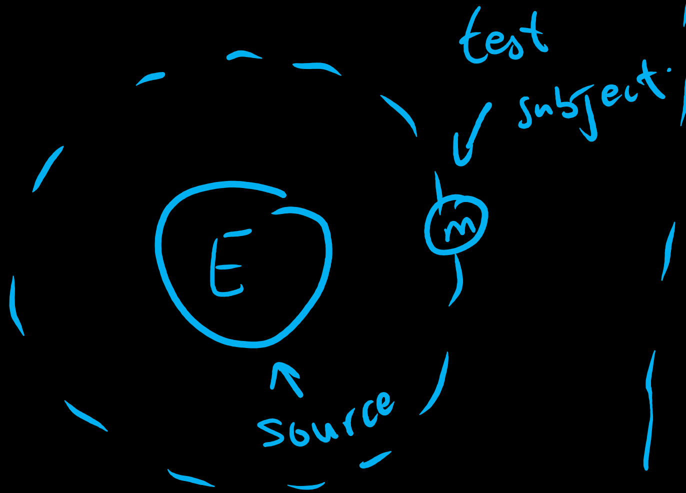
5. The radius of the Moon's orbit around the Earth is r and the period of the orbit is 27.3 days. The masses of the Earth and Moon are 6.0×10^{24} kg and 7.4×10^{22} kg respectively. Calculate the radius of the Moon orbit.

T

$m_E = 6 \times 10^{24}$ kg

$\boxed{m_m = 7.4 \times 10^{22}\text{ kg}}$

$R_m = ?$



$$\left(T = 2\pi\sqrt{\frac{r^3}{GM}}\right)^2$$

$$T^2 = \frac{4\pi^2 r^3}{GM_E}$$

$$r^3 = \frac{GM_E T^2}{4\pi^2}$$

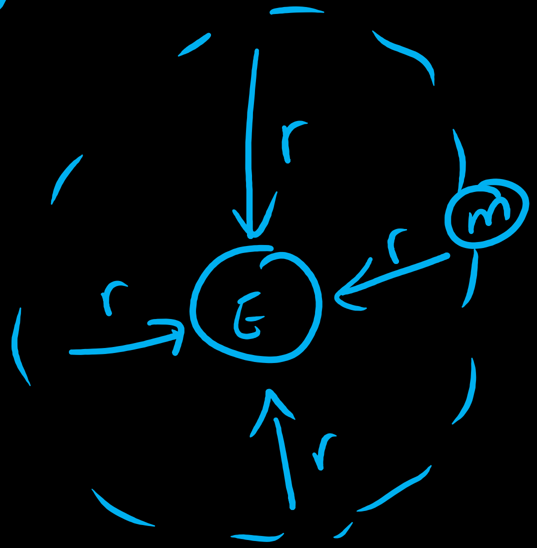
$$r^3 = \frac{(6.67)(6)(27.3 \times 24 \times 60 \times 60)^2}{4\pi^2}\left[10^{-11+24}\right]$$

$$r = 3.835 \times 10^8 \text{ m}$$

#

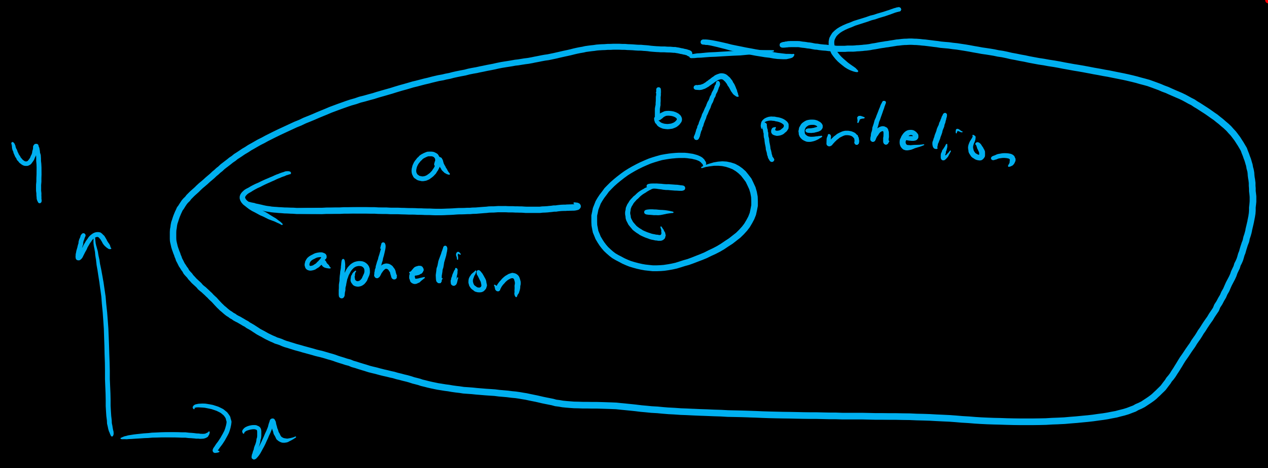
Model vs Real

Kepler's Law of Planetary motion



model

$$x^2+y^2=r^2$$



ellipsoid (real world)

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$$

Sample Problem 2

$g = 9.81\,ms^{-2}$?

2. Given that the gravitational field strength on the surface of the Earth is and the radius of the Earth is 6400 km. Find

   a) the minimum energy needed to send a rocket of mass 4500 kg from the surface of the Earth to infinity. $= U$.

   b) the escape velocity of the rocket.

a)

$U = -\frac{G m_1 m_2}{r}$ ← Syllabus bilang ada negative

$= -\frac{(6.67)(4500)(5.972)}{6400}\left(10^{-11+24-3}\right)$

$U \approx -2.8 \times 10^{11}$ J

b) $E_k = E_p$

$\frac{1}{2} \cancel{m_R} v^2 = \frac{G \cancel{m_R} m_E}{r}$

$v^2 = \frac{2 G m_E}{r}$

$v = \left(\frac{2 G m_E}{r}\right)^{1/2}$

$v = \left(\frac{2(6.67)(6)}{6400}\left[10^{-11+24-3}\right]\right)^{1/2}$

$\boxed{v \approx 1.11 \times 10^4\,ms^{-1}}$

Sample Problem 2

2. Given that the gravitational field strength on the surface of the Earth is and the radius of the Earth is 6400 km. Find

   a) the minimum energy needed to send a rocket of mass 4500 kg from the surface of the Earth to infinity.

   b) the escape velocity of the rocket.

Sample Problem 3

$m_m \approx 7.34 \times 10^{22}$

2. The moon has a mass of and a radius of 1740 km.

   a) A probe of mass 100 kg is dropped from a height 1 km onto the Moon's surface. Calculate its change in gravitational potential energy.

   b) If all the gravitational potential energy lost is converted to kinetic energy, calculate the speed at which the probe hits the surface.

2) a) $m_p = 100\,kg$

$h_i = 1\,km$

$h_f = 0$

1km

E_{gh}

0

moon

$\boxed{E_{gp} = mgh}$

$\boxed{g_m} = a_g = \dfrac{G m}{r^2}$ mass of moon

$g_E = \boxed{9.81\,ms^{-2}}$

$F = ma = mg$ moon

$g_m = \dfrac{G m_m}{r^2} = \dfrac{(6.67)(7.34)}{(1740)^2}\left[10^{-11+22-3-3}\right]$

$g_m \approx 1.62\,ms^{-2}$

$E_{gp} = m_p g_m h = (100)(1.62)(1000)$

$E_{gp} \approx 1.62 \times 10^5\,J$ #

Sample Problem 3

2. The moon has a mass of and a radius of 1740 km.

   a) A probe of mass 100 kg is dropped from a height 1 km onto the Moon's surface. Calculate its change in gravitational potential energy.

   b) If all the gravitational potential energy lost is converted to kinetic energy, calculate the speed at which the probe hits the surface.

$F = ma = mg$

$W = mg$

Earth

$g(\hat{m})$

Sample Problem 3

2. The moon has a mass of and a radius of 1740 km.

   a) A probe of mass 100 kg is dropped from a height 1 km onto the Moon's surface. Calculate its change in gravitational potential energy.

   b) If all the gravitational potential energy lost is converted to kinetic energy, calculate the speed at which the probe hits the surface.

THANK YOU!

6 September 2021

VII. ROTATION OF RIGID BODIES

Time allocation:
1h (Lecture) + 4h (Tutorial)
Learning Outcomes:

1. Define and use:
   - Angular displacement, θ.
   - Average angular velocity, ω_{ave}.
   - Instantaneous angular velocity, ω.
   - Average angular acceleration, α_{ave}.
   - Instantaneous angular acceleration, α.
2. Relate rotational parameters with their corresponding linear parameters:
   $$s = r\theta;\ v = r\omega;\ a_{trans.} = r\alpha,$$
   $$a_{centri.} = r\omega^2 = \frac{v^2}{r}$$
3. Solve constant angular acceleration rotational motion problems:
   $$\omega = \omega_o + \alpha t;$$
   $$\theta = \omega_o t + \frac{1}{2}\alpha t^2$$
   $$\omega^2 = \omega_o^2 + 2\alpha\theta$$
4. Define torque, $\vec{\tau} = \vec{r} \times \vec{F}$.
5. Solve uniform rigid body equilibrium problems.
6. Define and use the moment of inertia of a uniform rigid body (sphere, cylinder, ring, disc and rod).
7. State and use torque, $\tau = I\alpha$.
8. Define and use angular momentum, $L = I\omega$
9. State and use the principle of angular momentum conservation.

Rotational kinematics & dynamics

2nd

linear → rotational

rad

rad s^{-1}

rad s^{-2}

Chapter 2 ← linear kinematics

$V_{ave} = \dfrac{x_f - x_i}{t_f - t_i}$

$\omega_{ave} = \dfrac{\theta_f - \theta_i}{t_f - t_i}$

Chapter 4: Forces } linear

Chapter 4: F=ma

chapter 3

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9. State and use the principle of angular momentum conservation.

linear	rotational
$V = u + at$	$\omega = \omega_o + \alpha t$
$S = ut + \frac{1}{2}at^2$	$\theta = \omega_o t + \frac{1}{2}\alpha t^2$
$V^2 = u^2 + 2as$	$\omega^2 = \omega_o^2 + 2\alpha\theta$

$V \longrightarrow \omega$

$u \longrightarrow \omega_o$

$s \longrightarrow \theta$

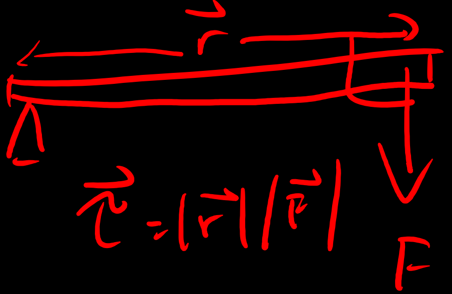
$a \longrightarrow \alpha$

VII. ROTATION OF RIGID BODIES

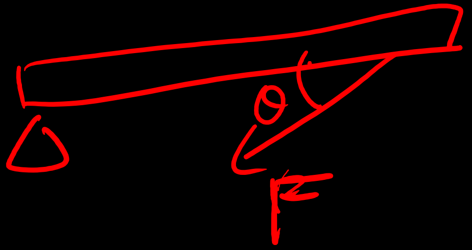
Time allocation:
1h (Lecture) + 4h (Tutorial)
Learning Outcomes:

1. Define and use:
   - Angular displacement, θ.
   - Average angular velocity, ω_{ave}.
   - Instantaneous angular velocity, ω.
   - Average angular acceleration, α_{ave}.
   - Instantaneous angular acceleration, α.
2. Relate rotational parameters with their corresponding linear parameters:
$$s = r\theta;\ v = r\omega;\ a_{trans.} = r\alpha,$$
$$a_{centri.} = r\omega^2 = \frac{v^2}{r}$$
3. Solve constant angular acceleration rotational motion problems:
$$\omega = \omega_o + \alpha t;$$
$$\theta = \omega_o t + \frac{1}{2}\alpha t^2$$
$$\omega^2 = \omega_o^2 + 2\alpha\theta$$
4. Define torque, $\vec{\tau} = \vec{r} \times \vec{F}$.
5. Solve uniform rigid body equilibrium problems.
6. Define and use the moment of inertia of a uniform rigid body (sphere, cylinder, ring, disc and rod).
7. State and use torque, $\tau = I\alpha$.
8. Define and use angular momentum, $L = I\omega$
9. State and use the principle of angular momentum conservation.

$\vec{\tau} = \vec{r} \otimes \vec{F}$



$\vec{\tau} = |\vec{r}||\vec{F}|$



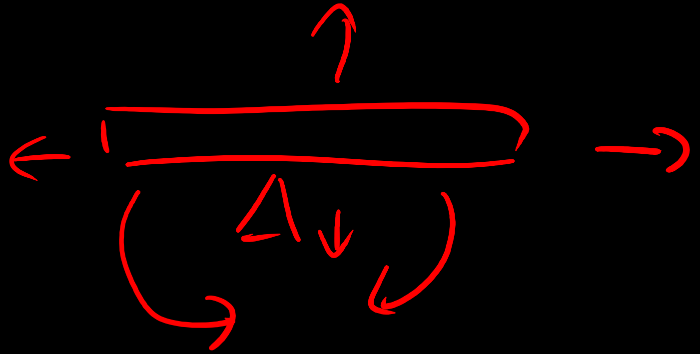
$\vec{\tau} = \vec{r} \times \vec{F}$

$\vec{\tau} = |\vec{r}||\vec{F}| \sin\theta$

$\sum F = 0$ — (1)

+

$\sum \tau = 0$ — (2)



x: left & right

y: up & down

θ: clockwise & anticlockwise

VII. ROTATION OF RIGID BODIES

Time allocation:
1h (Lecture) + 4h (Tutorial)
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1. Define and use:
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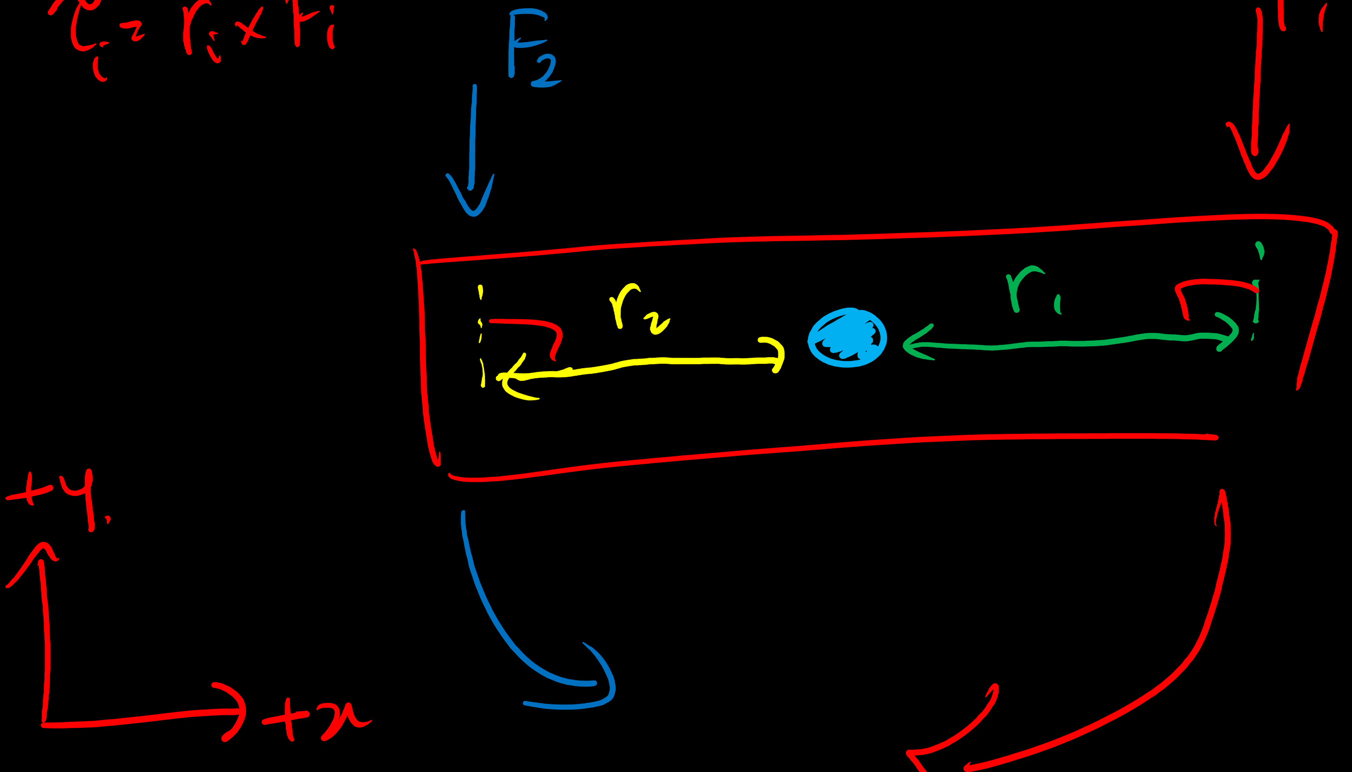
5. Solve uniform rigid body equilibrium problems.
6. Define and use the moment of inertia of a uniform rigid body (sphere, cylinder, ring, disc and rod).
7. State and use torque, $\tau = I\alpha$.
8. Define and use angular momentum, $L = I\omega$
9. State and use the principle of angular momentum conservation.

$$\vec{\tau}_i = \vec{r}_i \times \vec{F}_i$$



$$\sum \tau = 0 \rightarrow \tau_1 + (-\tau_2) = 0$$

$$\tau_2 = \tau_1$$

$$|\vec{r}_1||\vec{F}_1| \cancel{\sin 90} = |\vec{r}_2||\vec{F}_2| \cancel{\sin 90}$$

$$r_1 F_1 = r_2 F_2 \ \#$$

VII. ROTATION OF RIGID BODIES

Time allocation:
1h (Lecture) + 4h (Tutorial)
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9. State and use the principle of angular momentum conservation.

Condition for rotation equilibrium

$$\Rightarrow \sum \tau = 0$$

$$\tau_{clockwise} = \tau_{anticlockwise}$$

$x, y \Rightarrow$ ~~tra~~ translation equilibrium

$$\sum F_x = 0$$

$$\sum F_y = 0.$$

Time allocation:
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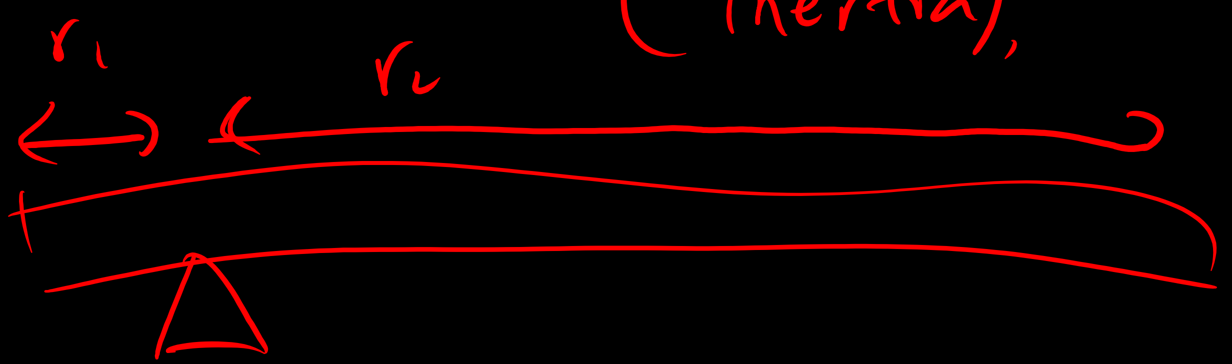
$\boxed{\text{Inertia}}$

$\tau (r, F)$

$\boxed{\text{Moment of inertia}}$

rotation ~~equ~~ analogous, of mass
(inertia),



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τ

By definition

$$\vec{\tau} = \vec{r} \times \vec{F}$$

By analogous of Newton's 2nd Law

$$F = ma$$

$$\boxed{\tau = I\alpha}$$

VII. ROTATION OF RIGID BODIES

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Linear momentum

$$P = m v$$

rotation -

$$L = I \omega$$

angular momentum.

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Linear

$$\Sigma P = 0$$

$$P_f = P_i$$

Rotational

$$\Sigma L = 0 \leftarrow \text{Konsep}$$

$$\Uparrow$$

ada markah dalam exam/assignments

$$L_f = L_i$$

VII. ROTATION OF RIGID BODIES

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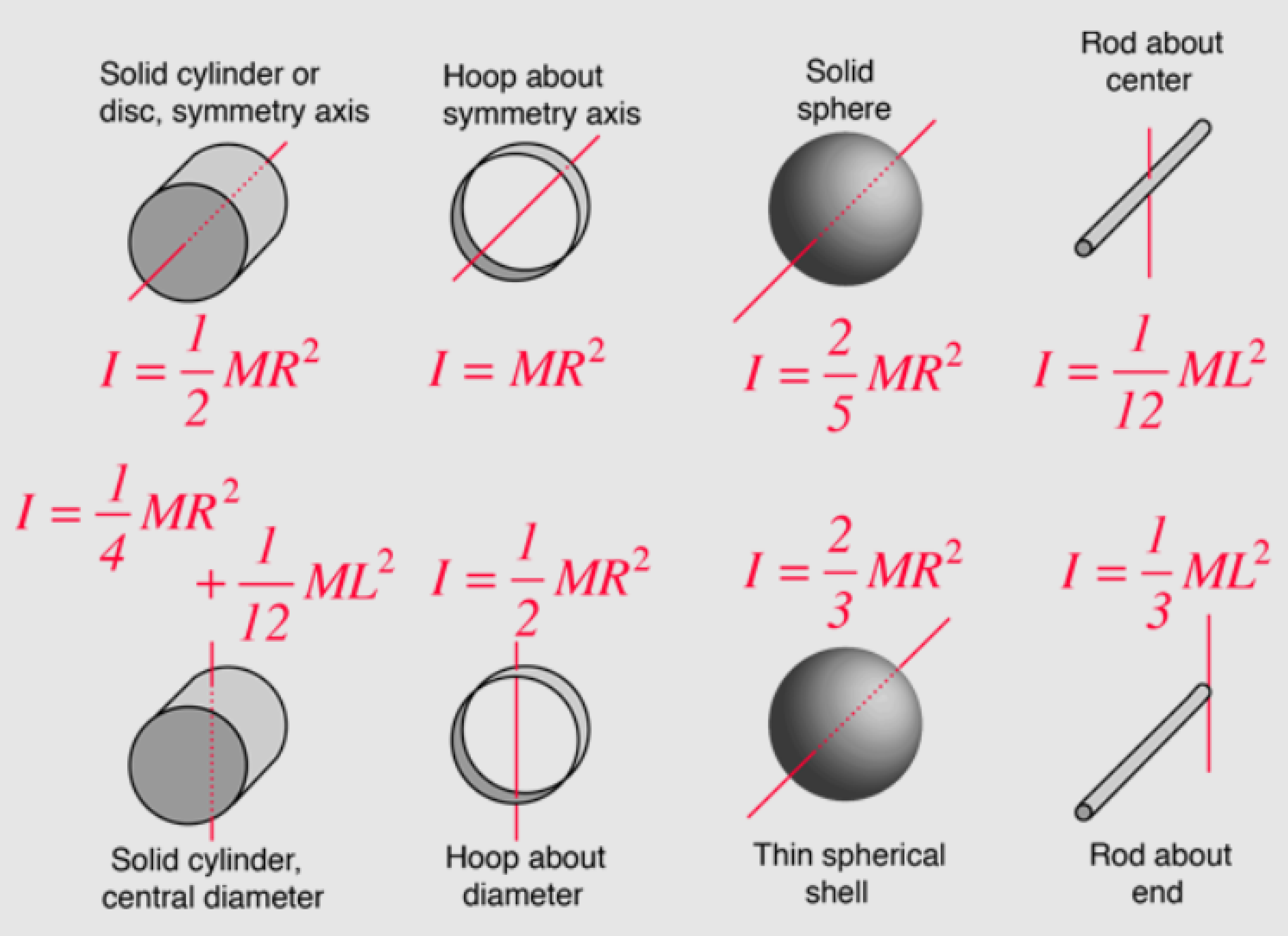

VII. ROTATION OF RIGID BODIES

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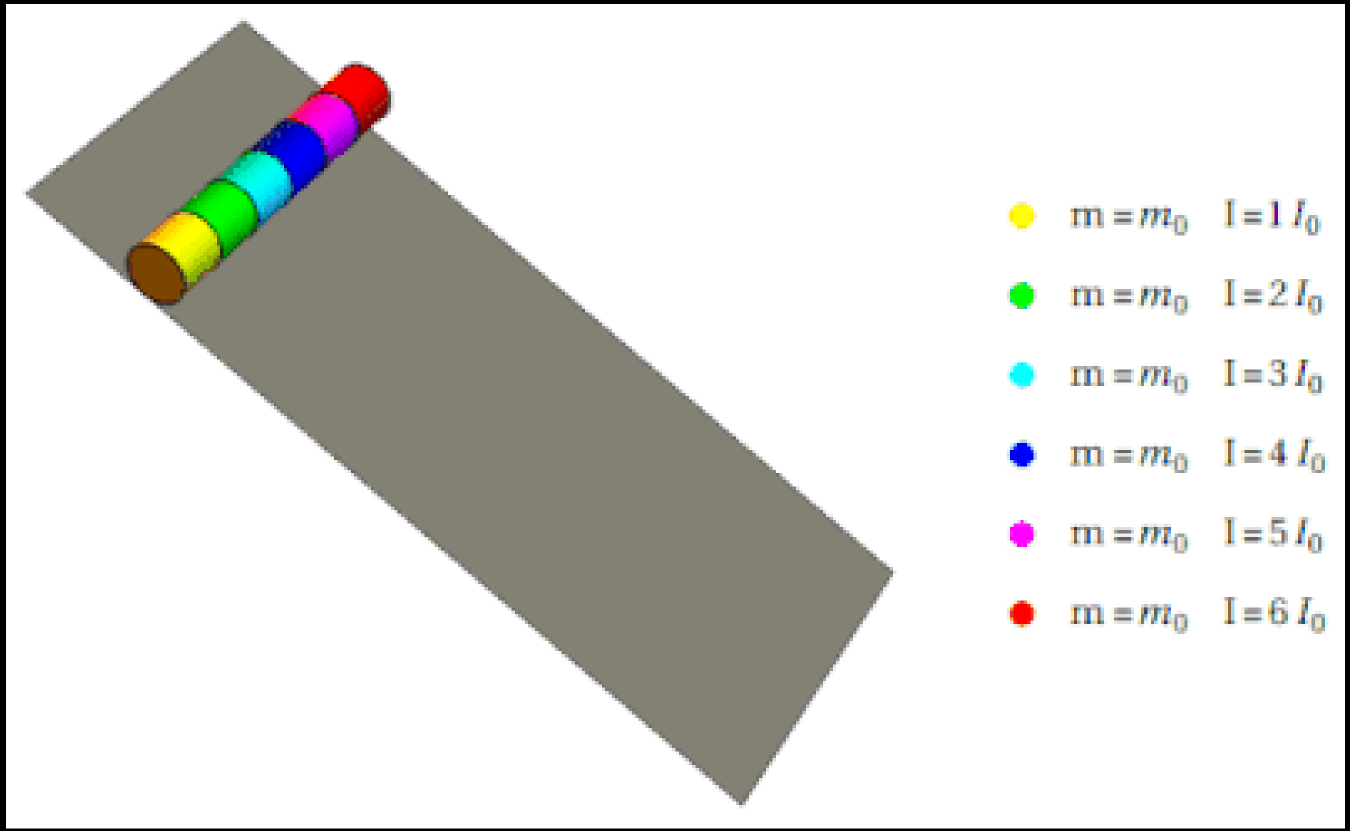


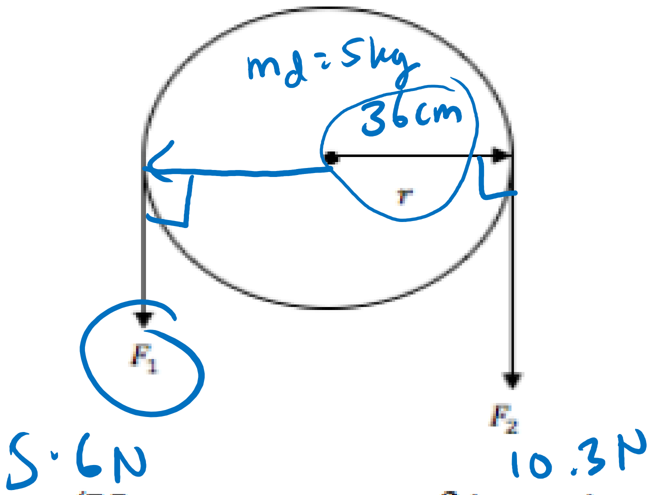
The bigger the moment of inertia, the "harder" it is to roll.

Thank you!

7th September 2021

Problem 1

3. Forces, $F_1 = 5.6N$ and $F_2 = 10.3N$ are applied tangentially to a disk with radius 36 cm and mass 5.0 kg as shown in figure below.

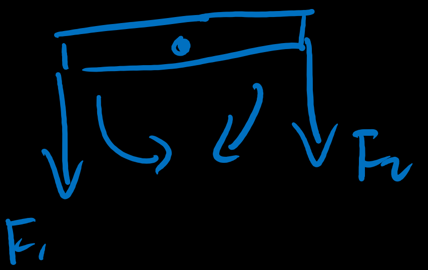


Calculate:

a) The net torque on the disk τ

b) The magnitude of angular acceleration of the disk α

(Use moment of inertia about the centre mass, $I = \frac{1}{2}MR^2$)



$M_{disk} \longrightarrow \boxed{I_{disk}}$

Problem 1

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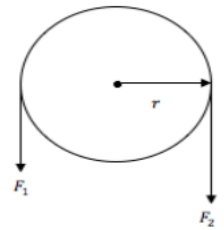


Calculate:

a) The net torque on the disk

b) The magnitude of angular acceleration of the disk

(Use moment of inertia about the centre mass, $I = \frac{1}{2}MR^2$)

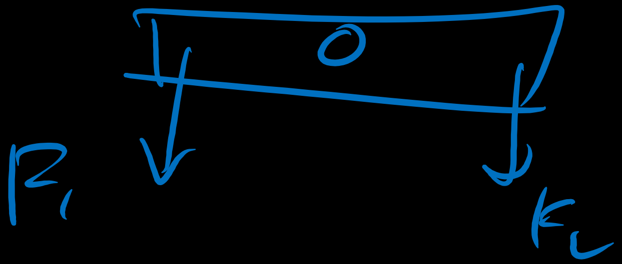
$\tau = \vec{r} \times \vec{F}$

does not take into account I_{disk}.

$F = ma$

$\tau = I\alpha$

① Look at how much torque the disk is experiencing



$\sum \tau_{net} = \boxed{\tau_{cl} + \tau_{anti}}$

Problem 1

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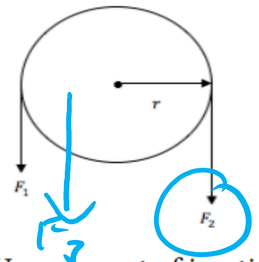

Calculate:

a) The net torque on the disk

b) The magnitude of angular acceleration of the disk

(Use moment of inertia about the centre mass, $I = \frac{1}{2}MR^2$

$$\sum \tau = \tau_1 + \tau_2$$

$$= |\vec{r}_1||\vec{F}_1| + |\vec{r}_1||\vec{F}_2|$$

$$= |\vec{r}_1|(|\vec{F}_1| + |\vec{F}_2|)$$

choose clockwise positive

$$= |\vec{r}_1|(\cancel{F_2} - |\vec{F}_1| + |\vec{F}_2|)$$

$$= (0.36m)(10.3 - 5.6)$$

$$\boxed{\sum \tau \simeq 1.692 \, Nm \text{ (clockwise).}}$$

$$\boxed{\vec{\tau} = \vec{r} \times \vec{F}}$$

Problem 1

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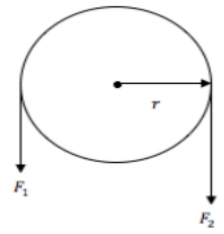


Calculate:

a) The net torque on the disk

b) The magnitude of angular acceleration of the disk

(Use moment of inertia about the centre mass, $I = \frac{1}{2}MR^2$

$$\tau = I\alpha$$

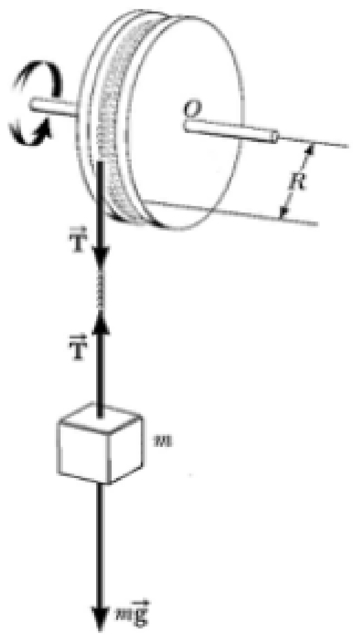
$$\tau_{net} = \left(\frac{1}{2}MR^2\right)\alpha$$

$$\alpha = \frac{2\tau_{net}}{MR^2} = \frac{2(1.692)}{5(0.36)^2}$$

$$\alpha \approx 5.22\ \text{rad s}^{-2}$$

Problem 2

4. An object of mass $m = 1.50kg$ is suspended from a frictionless pulley of radius $R = 20.0cm$ by a light string as shown in figure below. The pulley has a moment of inertia, I of $0.020kgm^2$ about the axis of the pulley. The object is released from rest.



Assume that the string does not slip on the pulley. After, $t = 3.0s$ determine:

a) The linear acceleration of the object $a(t=3s)$

b) The angular acceleration of the pulley $\alpha(t=3s)$

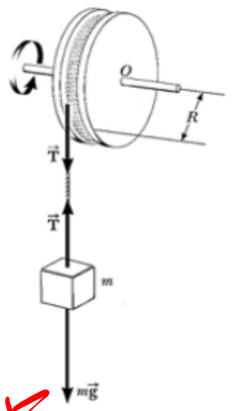
c) The tension in the string T

d) The linear velocity of the object v

Problem 2

$\alpha = \frac{a}{r}$

4. An object of mass $m = 1.50kg$ is suspended from a frictionless pulley of radius $R = 20.0cm$ by a light string as shown in figure below. The pulley has a moment of inertia, I of $0.020kgm^2$ about the axis of the pulley. The object is released from rest.



J&K

Assume that the string does not slip on the pulley. After, $t = 3.0s$ determine:

a) The linear acceleration of the object a

b) The angular acceleration of the pulley α

c) The tension in the string T

d) The linear velocity of the object v

$\sum \vec{F}_y = m a_g - \vec{T} = ma$

$a_g = 9.81ms^{-2}$

$\vec{\tau}_{net} = \vec{r} \times \vec{T}$

$\tau = rT \leftarrow ①$

$\boxed{T = \frac{\tau}{r}}$

$\tau = I\alpha$

$\tau = I\alpha$

disk

$I = \frac{1}{2} m r^2$

$I = \frac{1}{2} mR^2$

$\tau = \frac{1}{2} mR^2 \alpha$

$\alpha = \frac{a}{R}$

$\tau = \frac{1}{2} m\cancel{R^2}\left(\frac{a}{\cancel{R}}\right)$

$\boxed{\tau} = \frac{1}{2} m\cancel{R} a = T\cancel{R}$

Salah sebab

$m_d = m_{obje}$

$$\boxed{T = \frac{1}{2} ma}$$

mass block

$m a_g - ma = \frac{1}{2} ma$

$m a_g = \frac{3}{2} ma$

$a = \frac{2a_g}{3} \approx 6.54ms^{-2}$

Problem 2

$m = 1.5\,kg$

$R = 0.2\,m$

$I = 0.02\,kg\,m^2$

$u =$

$t = 3s$

$\tau = I\alpha$

(a)

$\sum F_y = ma$

$ma = mg - T$

$\tau = T \times r$

$T = \frac{\tau}{r}$

$\tau = \frac{I a_t}{r}$

$ma = mg - \frac{\tau}{r}$

$ma = mg - \frac{I a_t}{r^2}$

$\alpha = \frac{a}{r}$

$\tau = I\alpha$

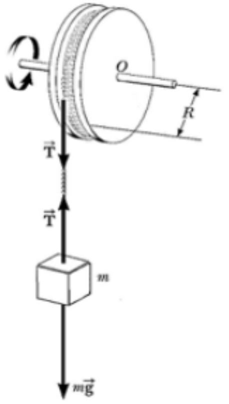
$\tau = \frac{I a_t}{r}$

$(1.5)a = (1.5)(9.81) - \frac{(0.02)(a)}{0.2^2}$ ← sub.

$2a = 14.715$

$a = 7.3575$ ← JU

4. An object of mass $m = 1.50kg$ is suspended from a frictionless pulley of radius $R = 20.0cm$ by a light string as shown in figure below. The pulley has a moment of inertia, I of $0.020kgm^2$ about the axis of the pulley. The object is released from rest.



Assume that the string does not slip on the pulley. After, $t = 3.0s$ determine:

a) The linear acceleration of the object

b) The angular acceleration of the pulley

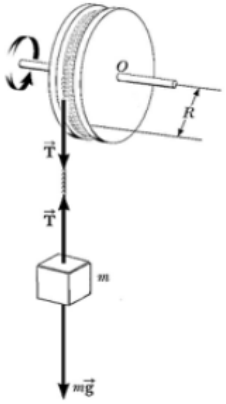
c) The tension in the string

d) The linear velocity of the object

Betul.

Problem 2

4. An object of mass $m = 1.50kg$ is suspended from a frictionless pulley of radius $R = 20.0cm$ by a light string as shown in figure below. The pulley has a moment of inertia, I of $0.020kgm^2$ about the axis of the pulley. The object is released from rest.



Assume that the string does not slip on the pulley. After, $t = 3.0s$ determine:

a) The linear acceleration of the object

b) The angular acceleration of the pulley

c) The tension in the string

d) The linear velocity of the object

$\alpha = \frac{a}{r}$

$\Sigma F_y = T - mg$

$= ma - mg$

$\tau = I\alpha$

$\tau = I(\frac{a}{r})$

$\Sigma F_y r = I(\frac{a}{r})$

$\Sigma F_y = Ia$

$\boxed{ma - mg = Ia}$

$ma - Ia = mg$

$a(m - I) = mg$

$a = \frac{mg}{m - I}$

$\approx 9.94 ms^{-2}$

Scanned with CamScanner

T

τ,

Fernando:

Salah says equate $T = \tau$.

$F_{net} = \Sigma F_y = mg - T$

$ma = mg - T$

$T = mg - ma$

Salah!

Problem 2

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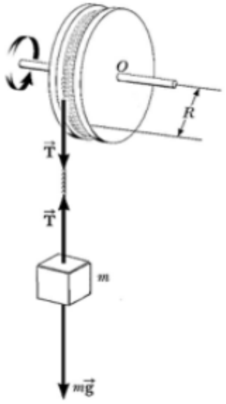

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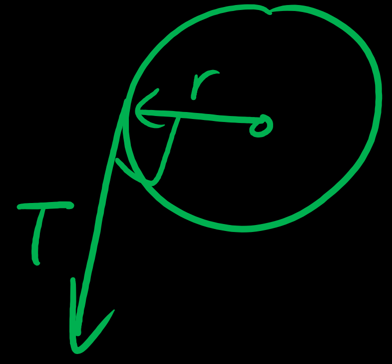
FBD

Sketch



$\sum F_y = mg - T.$

$\tau = I\alpha = rT.$ — 1

$\sum F_y = m_{block}\, g - T$ — 3

rearrange eqn 1 $\Rightarrow T = \frac{\tau}{r}$ — 2

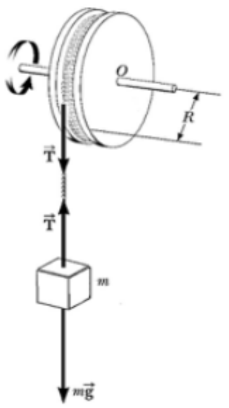
Sub 2 into 3

$\sum F_y = m_{block}\, g - \frac{\tau}{r}$

from $\tau = I\alpha$, sub in

Problem 2

4. An object of mass $m = 1.50kg$ is suspended from a frictionless pulley of radius $R = 20.0cm$ by a light string as shown in figure below. The pulley has a moment of inertia, I of $0.020kgm^2$ about the axis of the pulley. The object is released from rest.



Assume that the string does not slip on the pulley. After, $t = 3.0s$ determine:

a) The linear acceleration of the object

b) The angular acceleration of the pulley

c) The tension in the string $T = \frac{I\alpha}{r}$

d) The linear velocity of the object $v = r\omega = r\alpha t$

$$\sum F_y = m_b g - \frac{I\alpha}{r}$$

$$\sum F = ma$$

$$m_b a_t = m_b g - \frac{I\alpha}{r}$$

sub $\alpha = \frac{a_t}{r}$

$$m_b a_t = m_b g - \frac{I a_t}{r^2}$$

Rearrange for a

$$m_b a_t + \frac{I a_t}{r^2} = m_b g$$

$$a_t \left(m_b + \frac{I}{r^2}\right) = m_b g$$

$$a_t = \frac{m_b g}{\left(m_b + \frac{I}{r^2}\right)}$$

$$a_t = \frac{(1.5)(9.81)}{\left(1.5 + \frac{0.02}{(0.2)^2}\right)}$$

$$\approx 7.35 \, ms^{-2}$$

b)

$$\alpha = \frac{a_t}{r} = \frac{7.35}{0.2} = 36.75 \text{ rads}^{-2}$$

Problem 3

3. An ice skater spins with arms outstretched at 2.5 $revs^{-1}$. His moment of inertia at this time $1.5kgm^2$. He pulls his arms to increase his rate of spin. If his moment of inertia is $0.6kgm^2$ after he pulls in his arms, what is his new rate of rotation?

Next Session!

Problem 3

3. An ice skater spins with arms outstretched at 2.5 $revs^{-1}$. His moment of inertia at this time $1.5kgm^2$. He pulls his arms to increase his rate of spin. If his moment of inertia is $0.6kgm^2$ after he pulls in his arms, what is his new rate of rotation?

Danke Schon!

Chapter 1

- units
- dimension
- scalar vs vector

Chapter 2

Kinematics

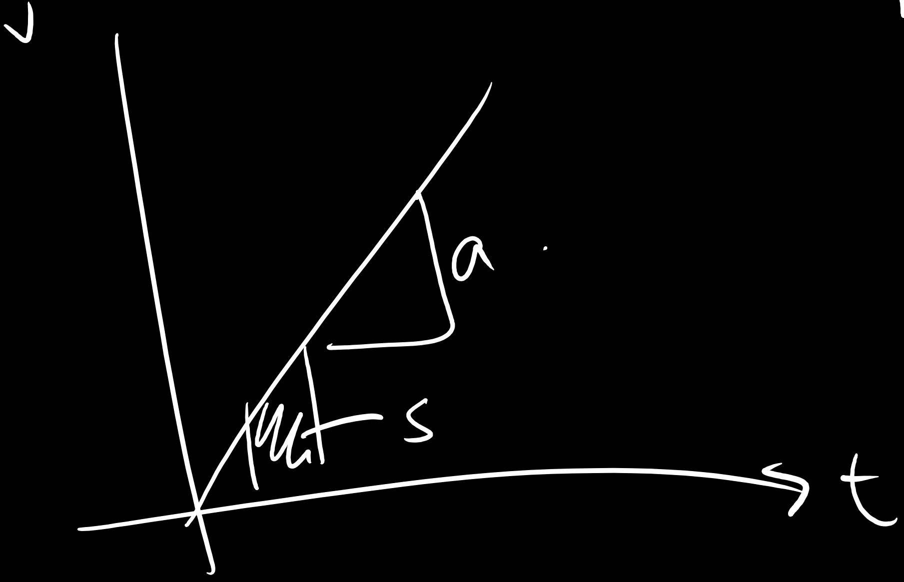
- definition ←
- graphs
- ~~equations~~

a_{ave} interval

$; \frac{v_f - v_i}{t_f - t_i}$

$a_{inst} = \frac{dv}{dt}$

rate of change



← gradient, area.

Chapter 3

Momentum & impulse

definition

Conservation of momentum

elastic & ~~inelastic~~ inelastic

Chapter 4: Forces

Definition

Newton's Law

$\boxed{\text{Equilibrium}} \rightarrow F_{net} = 0.$

8th September 2021

Application of Angular momentum.

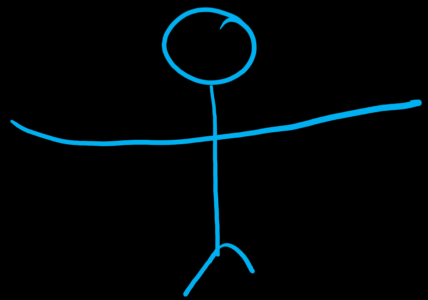
$p = mv \longrightarrow L = I\omega$

Problem Question 1

ω_i

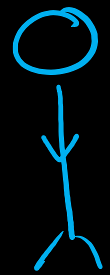
3. An ice skater spins with arms outstretched at 2.5 $revs^{-1}$. His moment of inertia at this time 1.5kgm^2. He pulls his arms to increase his rate of spin. If his moment of inertia is 0.6kgm^2 after he pulls in his arms, what is his new rate of rotation?

I_f I_i



$\omega = 2.5 \, revs^{-1}$

$I = 1.5 kgm^2$



ω?

$I = 0.6 kgm^2$

According to Conservation of angular momentum

$L_f = L_i$

$\Delta L = 0$

$L_f - L_i = 0$ ✓ 1 K1

eqn for $L_i = I_i \omega_i$

initial state	final state
$L_i = I_i \omega_i$	$L_f = I_f \omega_f$.

Problem Question 1

3. An ice skater spins with arms outstretched at 2.5 $revs^{-1}$. His moment of inertia at this time $1.5kgm^2$. He pulls his arms to increase his rate of spin. If his moment of inertia is $0.6kgm^2$ after he pulls in his arms, what is his new rate of rotation?

$$I_f \omega_f = I_i \omega_i$$

$$(1 \text{ rev} = 2\pi) \times 2.5$$

$$\frac{2.5 \text{ rev}}{1 s} = \frac{5\pi \text{ rad}}{1 s}$$

$$2.5 \text{ rev} s^{-1} = 5\pi \text{ rad } s^{-1} \quad 1$$

$$(0.6)(\omega_f) = (5\pi \cancel{\text{rad}})(1.5)$$

$$\omega_f = \frac{5(1.5)}{0.6} \pi \text{ rad } s^{-1} \quad 1 \quad G1$$

$$= 12.5\pi \text{ rad } s^{-1} \quad 1 \quad JU1.$$

$$\pi \simeq 3.14$$

$$\omega_f \simeq 12.5(3.14) \simeq 39.25 \text{ rad } s^{-1}$$

Problem Question 2

8. A 22-g bug crawls from the centre to the outside edge of a 150-g disk of radius 15.0 cm. The disk was rotating at 11.0 rad/s. What will be its final angular velocity? Treat the bug as a point mass.

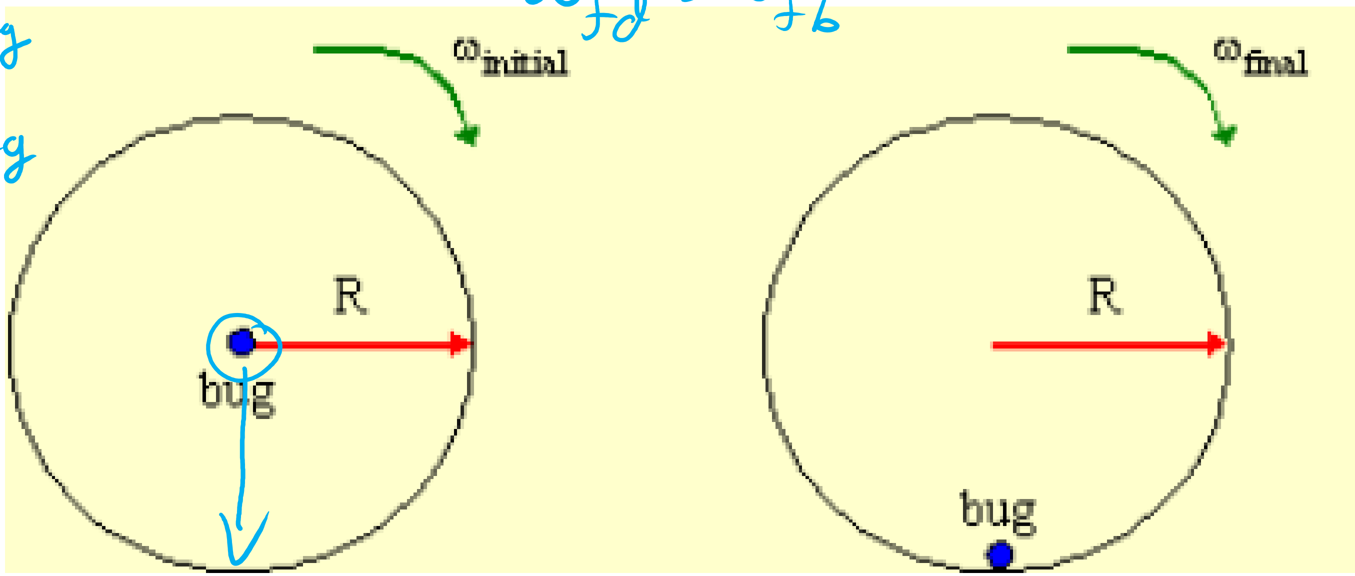
$\omega_{fd} = \omega_{fb}$

$m_b = 22g \simeq 0.022kg$

$m_d = 150g \simeq 0.15kg$

$r = 15cm \simeq 0.15m$

$\omega_{di} = 11 rads^{-1} = \omega_{bi}$



$L = I\omega$

$I_{bug} = m_b r^2$

(point mass)

$I_d = \frac{1}{2} m_d r^2$

$\Sigma L_f = \Sigma L_i$

Problem Question 2

8. A 22-g bug crawls from the centre to the outside edge of a 150-g disk of radius 15.0 cm. The disk was rotating at 11.0 rad/s. What will be its final angular velocity? Treat the bug as a point mass.

R

$$L_{bf} + L_{df} = L_{bi} + L_{di}$$

$$\underbrace{m_b R^2}_{I_b} \omega_f + \frac{1}{2} m_d R^2 \omega_f = \underbrace{m_b (0) \omega_i}_{0} + \frac{1}{2} m_d R^2 \omega_i$$

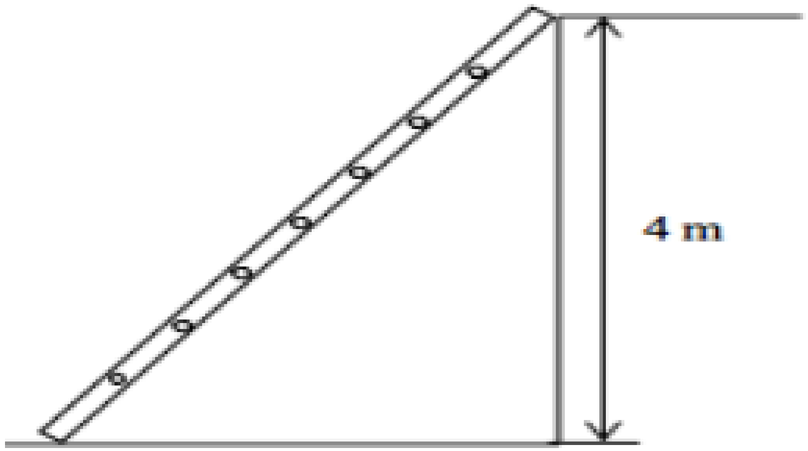
$$\omega_f \left(m_b \cancel{R^2} + \frac{1}{2} m_d \cancel{R^2} \right) = \frac{1}{2} m_d \cancel{R^2} \omega_i$$

$$\omega_f = \frac{\frac{1}{2} m_d \omega_i}{m_b + \frac{1}{2} m_d} = \frac{\frac{1}{2}(0.15\,\text{kg})(11\,\text{rad s}^{-1})}{(0.022) + (\frac{1}{2})(0.15)}$$

$$\boxed{\omega_f \approx 8.5\ \text{rad s}^{-1}}$$

Homework

2. A 5.0-m-long ladder leans against a smooth wall at a point 4.0 m above a cement floor as shown in figure below.



The ladder is uniform and has mass $m = 12.0kg$. Assuming the wall is frictionless (but the floor is not), determine the forces exerted on the ladder by the floor and by the wall.

Contoh untuk rujukan: https://physicstasks.eu/654/a-leaning-ladder

Fernado: 8.2 Q3

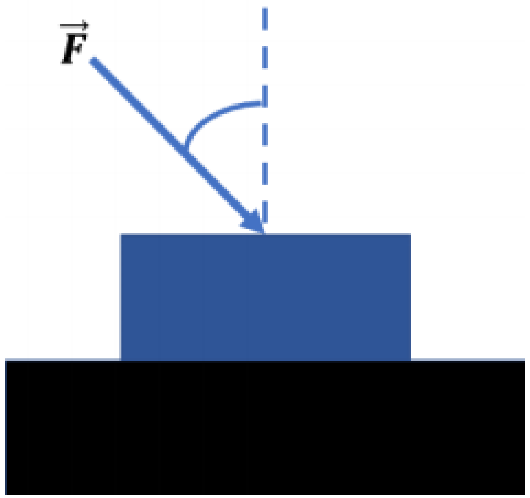
Thank you!

9th September 2021

Sample Problem 1

7. **(PSPM 12/13)**

(a) A 0.5 kg box is initially at rest on a smooth horizontal surface. It is acted upon by a horizontal force for a distance of 3 m. If the final speed of the box is $5ms^{-1}$, calculate the magnitude of the force.



(b) The figure above shows a $2.0kg$ block is being pushed along a rough surface by a force $F = 30N$ at an angle 60^o from the normal.

i. Sketch a free body diagram for the block. Use common symbol for each force.

ii. If the block moves at constant acceleration $0.5ms^{-2}$, calculate the coefficient of friction.

Sample Problem 1

7. (PSPM 12/13)

m_b $u = 0\ ms^{-1}$ $F_f = 0$

(a) A 0.5 kg box is initially at rest on a smooth horizontal surface. It is acted upon by a horizontal force for a distance of 3 m. If the final speed of the box is $5ms^{-1}$, calculate the magnitude of the force.

s v

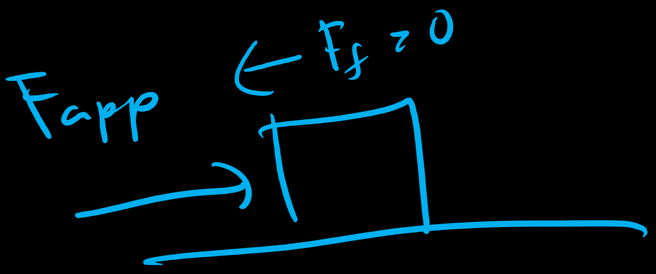
$$\boxed{F = ma}$$

$$v^2 = u^2 + 2as$$

$$5^2 = 0^2 + 2a(3)$$

$$25 = 6a$$

$$a = \frac{25}{6}\ ms^{-2}$$



no other force acting upon the box in x-axis

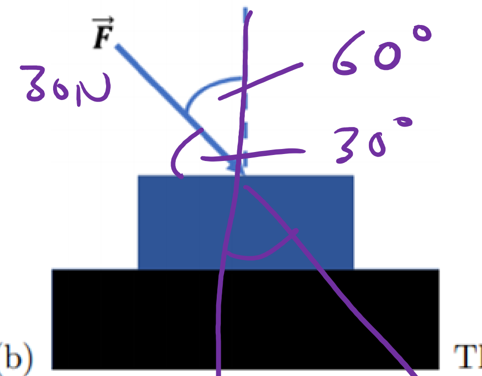
$$F_{applied} = m_b a$$

$$= 0.5\left(\frac{25}{6}\right)$$

$$= \frac{12.5}{6}$$

$$F_{applied} = 2.083 N$$

Sample Problem 1

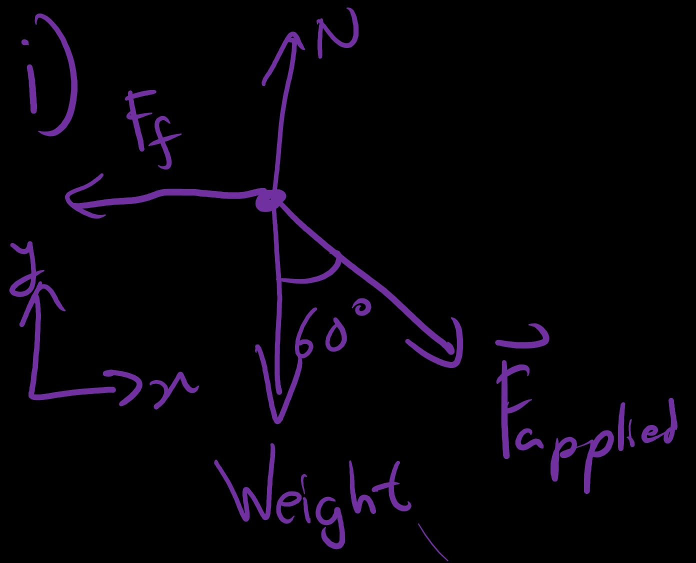


(b) The figure above shows a 2.0kg block is being pushed along a rough surface by a force $F = 30N$ at an angle 60^o from the normal.

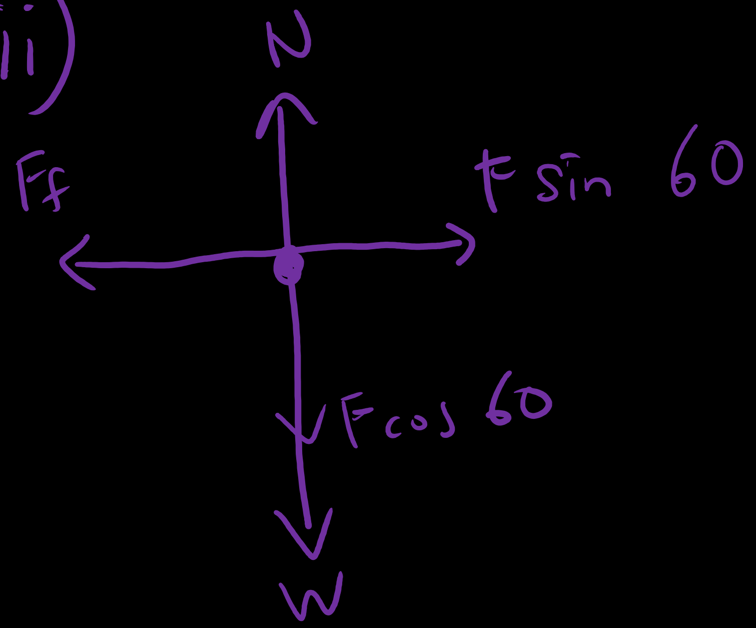
i. Sketch a free body diagram for the block. Use common symbol for each force.

ii. If the block moves at constant acceleration $0.5ms^{-2}$, calculate the coefficient of friction.

i)



ii)



$$\sum F_x = F_{app} \sin 60 - F_f$$

$$F_f = \mu N = \mu[F\cos 60 + W]$$

$$ma = F \sin 60 - \mu[F \cos 60 + W]$$

Sample Problem 1

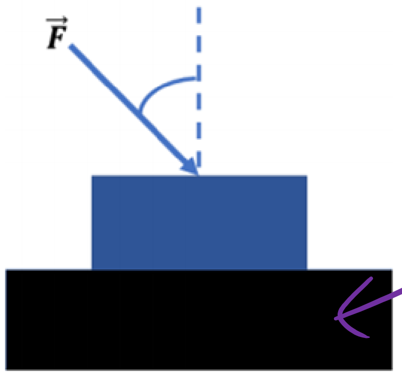
$ma = F\sin 60 - \mu[F\cos 60 + W]$.

$\frac{ma - F\sin 60}{F\cos 60 + W} = -\mu$

$\mu = \frac{F\sin 60 - ma}{F\cos 60 + mg}$

$= \frac{(30)\sin 60 - (2)(0.5)}{(30)\cos 60 + (2)(9.81)}$

$\boxed{\mu = 0.7216}$



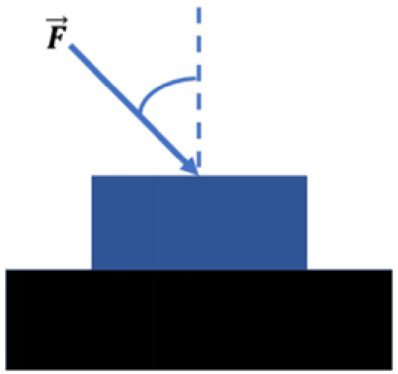
Surface aps?

(b) The figure above shows a $2.0kg$ block is being pushed along a rough surface by a force $F = 30N$ at an angle 60^o from the normal.

i. Sketch a free body diagram for the block. Use common symbol for each force.

ii. If the block moves at constant acceleration $0.5ms^{-2}$, calculate the coefficient of friction.

Sample Problem 1



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ii. If the block moves at constant acceleration $0.5ms^{-2}$, calculate the coefficient of friction.

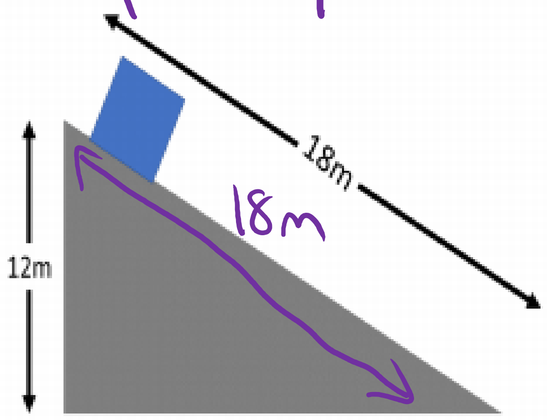
Sample Problem 2

why ΔE tak boleh pakai

8(b) past year

$E_{gp} \rightarrow E_k + E_{heat}$

you don't know the eqn



$u = 0$

$\mu = 0.19$

(b)

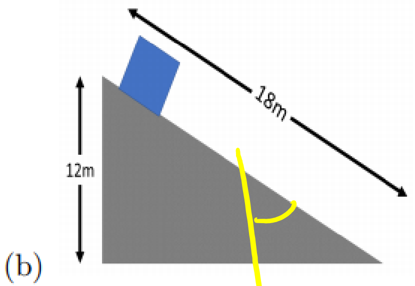
The figure shows a block held at rest at the top of a 18m long rough slope with a coefficient of kinetic friction of 0.19. The height of the box on the slope is 12m. When released, the block slides down.

v?

i. Calculate the final speed of the block at the bottom of the slope.

ii. If the mass of the block is increased, will the final speef of the block decrease, same or increase? Justify your answer.

Sample Problem 2

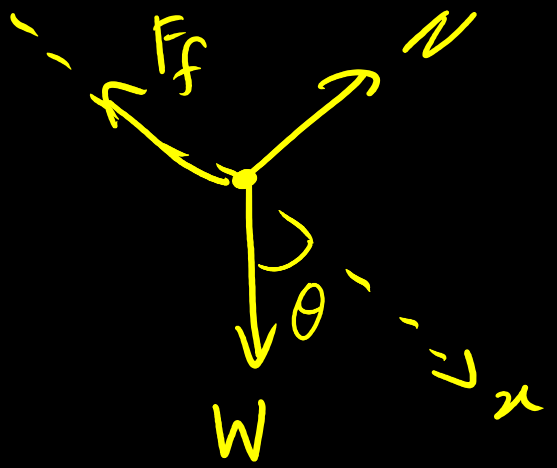


(b) The figure shows a block held at rest at the top of a 18m long rough slope with a coefficient of kinetic friction of 0.19. The height of the box on the slope is 12m. When released, the block slides down.

i. Calculate the final speed of the block at the bottom of the slope.

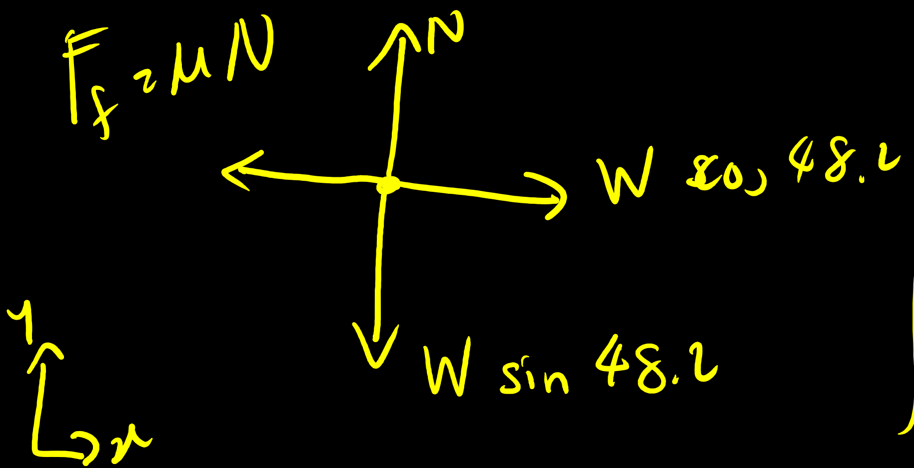
ii. If the mass of the block is increased, will the final speef of the block decrease, same or increase? Justify your answer.

FBD



$$\theta = \cos^{-1}\left(\frac{12}{18}\right) \approx 48.19^\circ$$

$F_f = \mu N$



$$\sum F_x = W\cos 48.2 - \mu N$$

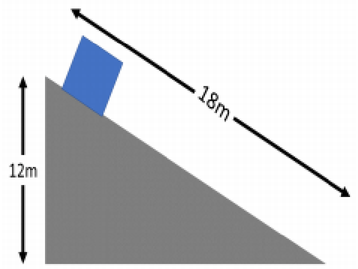
$$\cancel{m}a = \cancel{m}g\cos 48.2 - \mu \cancel{m}g\sin 48.2$$

$$a = g[\cos(48.2) - \mu \sin 48.2]$$

$$= 9.81[\cos(48.2) - (0.19)\sin 48.2]$$

$$a \approx 5.15\, ms^{-2}$$

Sample Problem 2



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i. Calculate the final speed of the block at the bottom of the slope.

ii. If the mass of the block is increased, will the final speef of the block decrease, same or increase? Justify your answer.

$$v^2 = u^2 + 2as \quad (u = 0)$$

$$v = [2(5.15)(18m)]^{1/2}$$

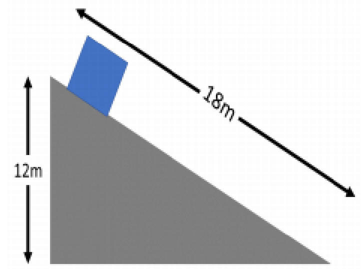
$$= 13.62 \, ms^{-1}$$

ii) Same.

~~mass~~

acceleration is independent of the mass in this case.

Sample Problem 2



(b) The figure shows a block held at rest at the top of a 18m long rough slope with a coefficient of kinetic friction of 0.19. The height of the box on the slope is 12m. When released, the block slides down.

i. Calculate the final speed of the block at the bottom of the slope.

ii. If the mass of the block is increased, will the final speef of the block decrease, same or increase? Justify your answer.

$$E_{gp} = m(9.81)(12)$$
$$= (117.72\,m)\ J$$

$$E_k = \tfrac{1}{2} m (13.62)^2$$
$$= 92.75\,m\ J.$$

Additional Info

$$\Delta E \Rightarrow E_{gp} = E_k + E_{heat}$$

$$E_{heat} = (117.72 - 92.75)\,m \text{ Joules}$$
$$E_{heat} = 24.97\,m \text{ Joules}$$ (gain by env. & loss by body)

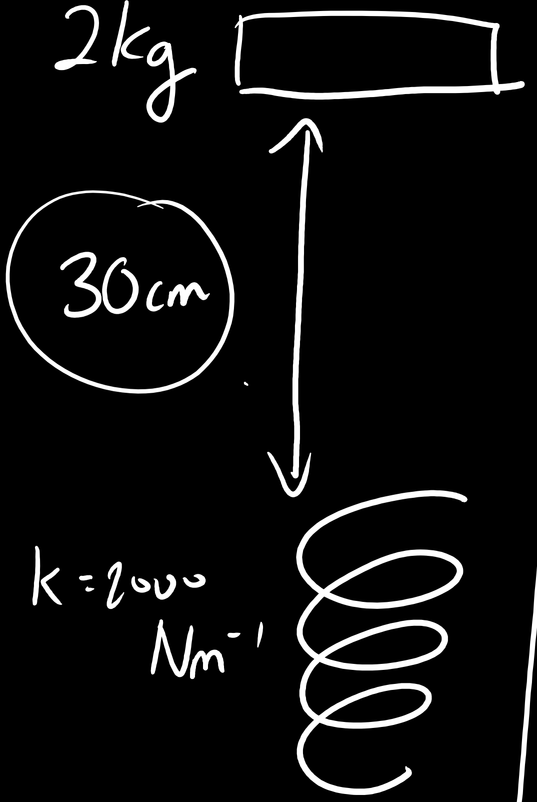
Thank you !

10. **(PSPM 18.19)**
A 2.0kg object is released vertically onto the top end of a vertical spring 30cm away. The spring constant is 2000Nm^{-1}.

E_k

(a) Calculate the speed of the object just before striking the spring

(b) Determine the maximum compression x.



a) $mgh \longrightarrow \frac{1}{2}mv^2$

$\Delta E_{gp} = mg\Delta h$

$\Delta E_k = \frac{1}{2}m(v^2 - \cancel{u^2}^{\,0})$

$\cancel{m}g\Delta h = \frac{1}{2}\cancel{m}v^2$

$v^2 = 2g\Delta h$

$V = \sqrt{2g\Delta h}$

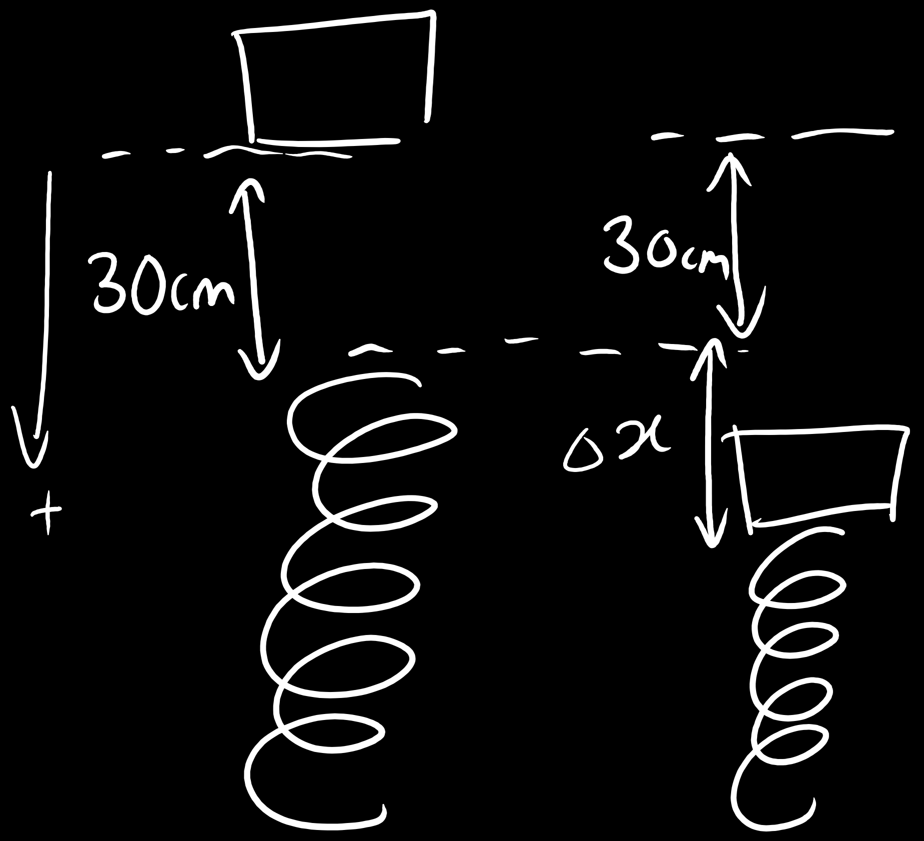
$= \sqrt{2(9.81)(0.3m)}$

$\boxed{V \approx 2.426 ms^{-1}}$

10. **(PSPM 18.19)**
A $2.0kg$ object is released vertically onto the top end of a vertical spring $30cm$ away. The spring constant is $2000Nm^{-1}$.

(a) Calculate the speed of the object just before striking the spring

(b) Determine the maximum compression x.



Energy Conversion: $E_{gp} = E_{ep}$.

$\Delta E_{gp} = mg\,\Delta h$

$\Delta E_{ep} = \frac{1}{2}k(\Delta x)^2$

$\Delta h = 0.3m + \Delta x$

$mg\,\Delta h = \frac{1}{2}k(\Delta x)^2$

$mg(0.3 + \Delta x) = \frac{1}{2}k(\Delta x)^2$

10. **(PSPM 18.19)**
A 2.0kg object is released vertically onto the top end of a vertical spring 30cm away. The spring constant is 2000Nm^{-1}.

(a) Calculate the speed of the object just before striking the spring

(b) Determine the maximum compression x.

$$\left(mg(0.3+\Delta x)=\frac{1}{2}k\Delta x^2\right)\times 2$$

$$2mg(0.3+\Delta x)=k\Delta x^2$$

$$k\Delta x^2-2mg\,\Delta x-2mg(0.3)=0$$

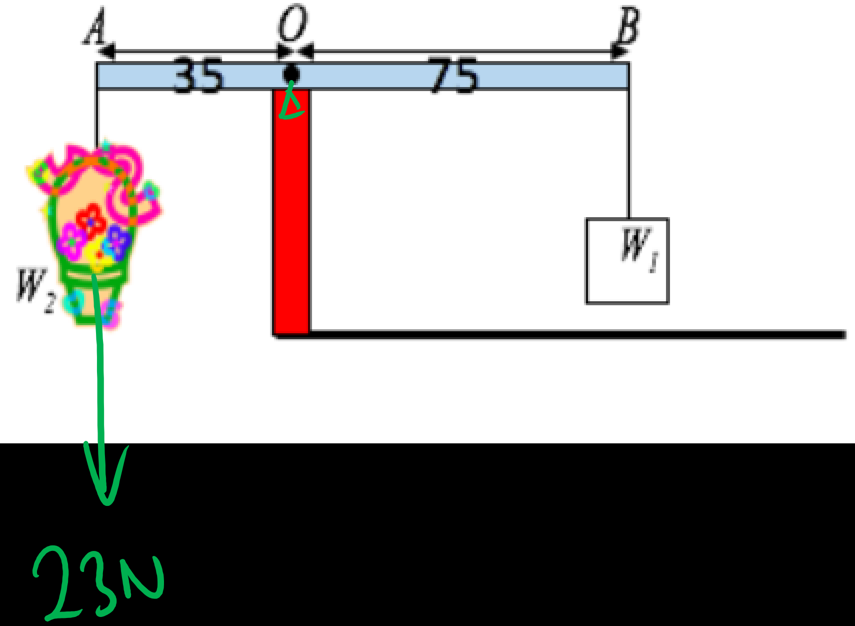
$$2000(\Delta x)^2-2(2)(9.81)\,\Delta x-2(2)(9.81)(0.3)=0$$

$$\Delta x=\{0.087,\ \cancel{-0.068}\}\ m$$

max compression

10 September 2021

3. A hanging flower basket having weight, $W_2 = 23N$ is hung out over the edge of a balcony railing on a uniform horizontal beam AB of length 110 cm that rests on the balcony railing. The basket is counterbalanced by a body of weight, W_1 as shown below.

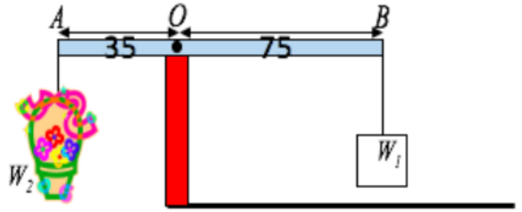


If the mass of the beam is 3.0 kg, calculate:

a) the weight, W_1 needed

b) the force exerted on the beam at point O

3. A hanging flower basket having weight, $W_2 = 23N$ is hung out over the edge of a balcony railing on a uniform horizontal beam AB of length 110 cm that rests on the balcony railing. The basket is counterbalanced by a body of weight, W_1 as shown below.



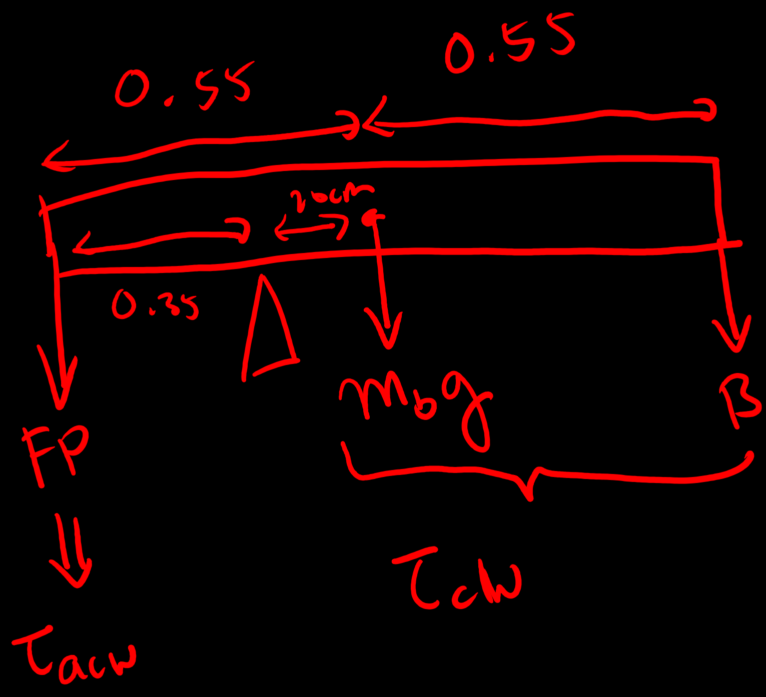
If the mass of the beam is 3.0 kg, calculate:

a) the weight, W_1 needed

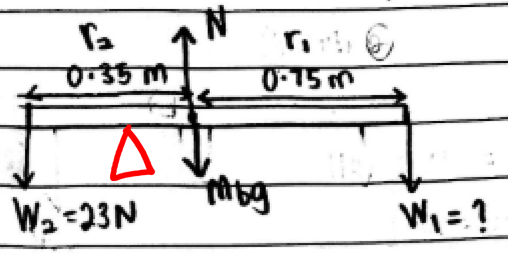
b) the force exerted on the beam at point O

Fernado

$\tau_{cw} = \tau_{acw}$



3.



$m_b g$

a) $\tau_1 = \tau_2$

$W_1 r_1 = W_2 r_2 - m_b g$

$W_1 = \dfrac{W_2 r_2 - m_b g}{r_1}$

$= \dfrac{(23)(0.35) - m_b g}{0.75}$

$W_1 \approx 10.73N - \dfrac{m_b g}{0.75} \simeq 2.89N$

b) $\sum F_x = N - W_2 - W_1 - m_b g = 0$

$N = W_2 + W_1 + m_b g$

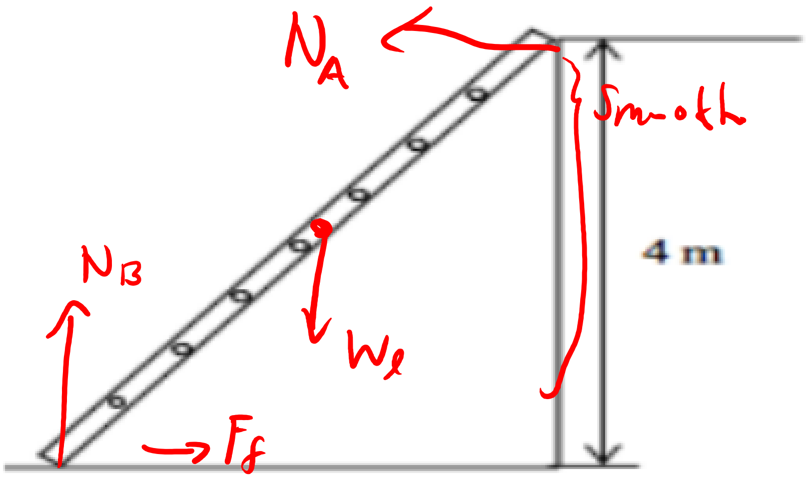
$= 23 + \cancel{10.73} + (3)(9.81)$ 2.89

$= 63.16\ N$

$\boxed{N = 55.3N}$

Ladder Problem

2. A 5.0-m-long ladder leans against a smooth wall at a point 4.0 m above a cement floor as shown in figure below.



The ladder is uniform and has mass m = 12.0kg. Assuming the wall is frictionless (but the floor is not), determine the forces exerted on the ladder by the floor and by the wall.

$\sum \tau = -\tau_{NA} + \tau_{NB} + \tau_W \Leftarrow$ clockwise $+$

Joseph

What is F_{fx} & F_{fy}?

$F_{fx} = N_A$

$F_{fy} = N_B$

$\sum F_x = 0$

$0 = F_{Fx} - F_w$

$F_{Fx} = F_w$

$\sum F_y = 0$

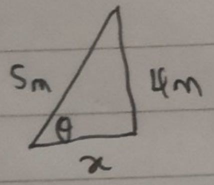
$0 = F_{Fy} - mg$

$F_{Fy} = mg$

$= (12)(9.81)$

$= 117.72 \text{ N}$

Triangle:



Pythagoras' theorem

$5^2 = 4^2 + x^2$

$x = 3\text{m}$

$\sin\theta = \frac{4}{5}$

$\theta = 53°$

Torque Forces:

τ_w N_A τ_{N_B}

$\sum \tau = 0$

$0 = (5)(F_w)(\sin 53°) - (2.5)(mg)(\sin 37) - 0$

$(F_w)(3.99) = 177$

$F_w = 44.3 \text{ N}$

$F_{Fx} = F_w$

$F_{Fx} = 44.3$

$F_{Fy} = 117.72$

$F^2 = (44.3)^2 + (117.72)^2$

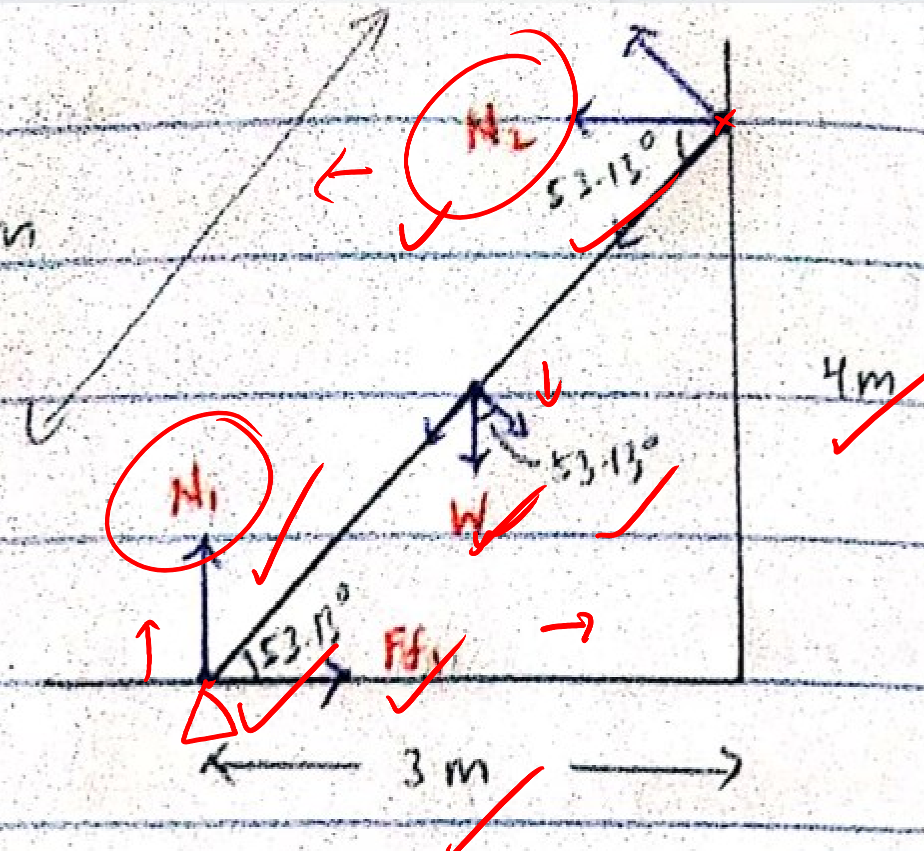
$F = 125.78 \text{ N}$

Kylie

$r_{N_2} = 5m$

2.

$m = 12.0 \text{ kg}$



$\tan\theta = \frac{4}{3}$

$\theta \approx 53.13°$

Kylie

to the right ; '+'

$\Sigma_x : F_{f_1} - N_2 = 0$

$F_{f_1} = N_2$

he takes positive

$\Sigma_y : N_1 - W = 0$

$N_1 = W$

$N_1 = mg$

$N_1 = (12)(9.81)$

$N_1 = 117.72\ N$

$\Sigma \tau = \tau_{acw} + \tau_{cw}$

fulcrum @ $N_1 \Rightarrow \tau_{N_1} = 0$

Moment of force : cw to be +.

$\Sigma \tau : -(5)(N_2 \sin\theta) + 2.5(W \cos\theta) = 0$

$2.5(mg \cos\theta) = 5(N_2 \sin\theta)$

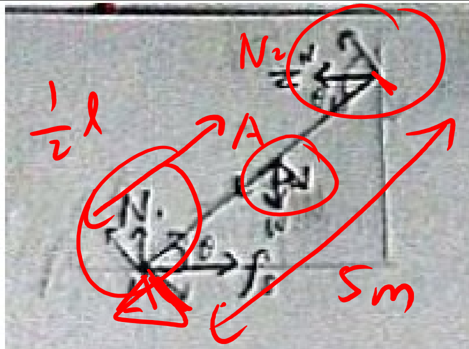
$N_2 = \frac{2.5(mg \cos\theta)}{5 \sin\theta}$

$N_2 = \frac{2.5(12)(9.81)(\cos 53.13)}{5 \sin 53.13°}$ 1

$N_2 \approx 44.15\ N$ 1

$\boxed{N_1 = 117.72\ N \quad N_2 \approx 44.15\ N}$

Farrah



g - gravitational acceleration const

wall is frictionless.

$\vec{F}_w + \vec{F}_g + \vec{F}_f + \vec{F}_{fy} = 0$

$\sum \tau = 0 \quad \sum F_x = 0 \quad \sum F_y = 0$

m = 12.0 kg

l = 5.0 m

$\theta = \sin^{-1}\left(\frac{4}{5}\right)$

$= 53.13°$

$\sum F_x = f_s - N_2$

$f_s = N_2$

$\mu N_1 = N_2$

$\mu(117.72) = N_2$

$\sum F_y = N_1 - W = 0$

$N_1 = W$

$N_1 = mg$

$N_1 = 12 \times 9.81$

$= 117.72$ N

N_1 Sebagai fulcrum

$\tau_{N_1} = 0$

$\sum \vec{\tau} = -N_2 \sin\theta (l) + W\cos\theta\left(\frac{1}{2}l\right) = 0$

$0 = -N_2 \sin 53.13°(5) + (117.72)\cos 53.13°\left(\frac{5}{2}\right)$

$N_2 \sin 53.13°(5) = 117.72 \cos 53.13°\left(\frac{5}{2}\right)$

$N_2 = \dfrac{117.72 \cos 53.13\left(\frac{5}{2}\right)}{\sin 53.13°(5)}$

$N_2 \approx 44.15$ N

$f_s = N_2$

$= 44.15$ N

Merci!

13 September 2021

VIII. SIMPLE HARMONIC MOTION

Time allocation:
1h (Lecture) + 8h (Tutorial)
Learning Outcomes:

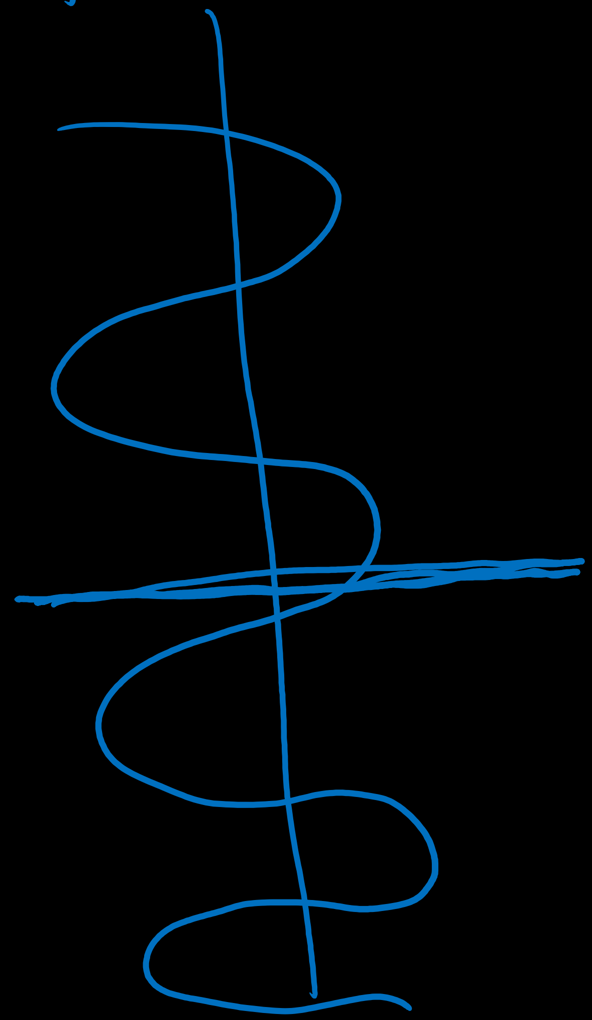
1. Explain SHM
2. Solve problems related to SHM displacement equation, $x = A\ sin\ (\omega t)$
3. Derive equations :
   - Velocity, $v = \frac{dx}{dt} = \pm\omega\sqrt{A^2 - x^2}$.
   - Acceleration, $a = \frac{dv}{dt} = -\omega^2 x$.
   - Kinetic energy, $K = \frac{1}{2}m\omega^2(A^2 - x^2)$.
   - Potential energy, $U = \frac{1}{2}m\omega^2 x^2$
4. Emphasise the relationship between total SHM energy and the amplitude
5. Apply equations for v, a, K and U for SHM
6. Discuss the following graphs:
   - Displacement-time
   - Velocity-time
   - Acceleration-time
   - Energy-displacement
7. Use expression for SHM period for simple pendulum and single spring

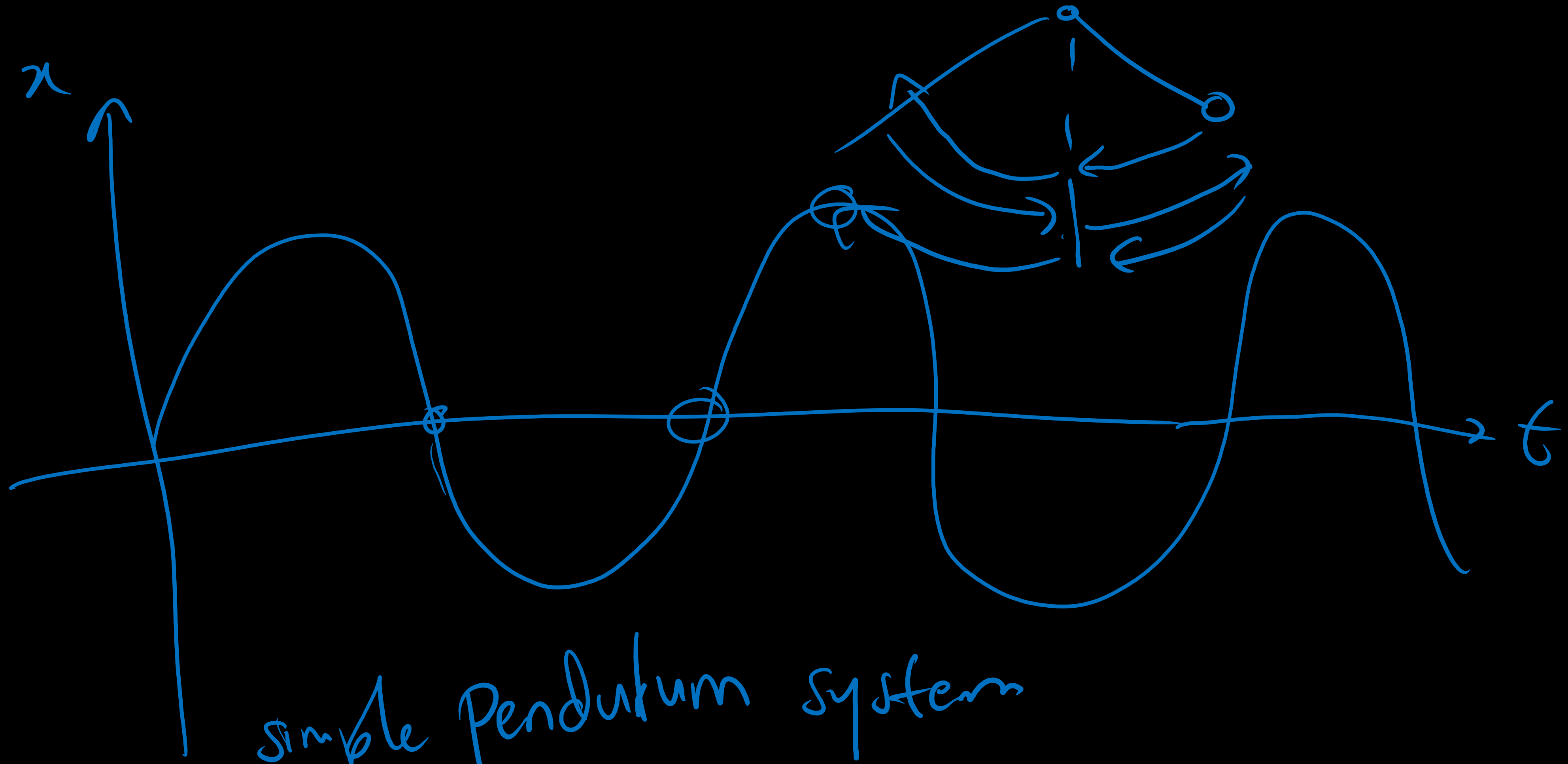
Emphasise SHM.

$a \propto -x$

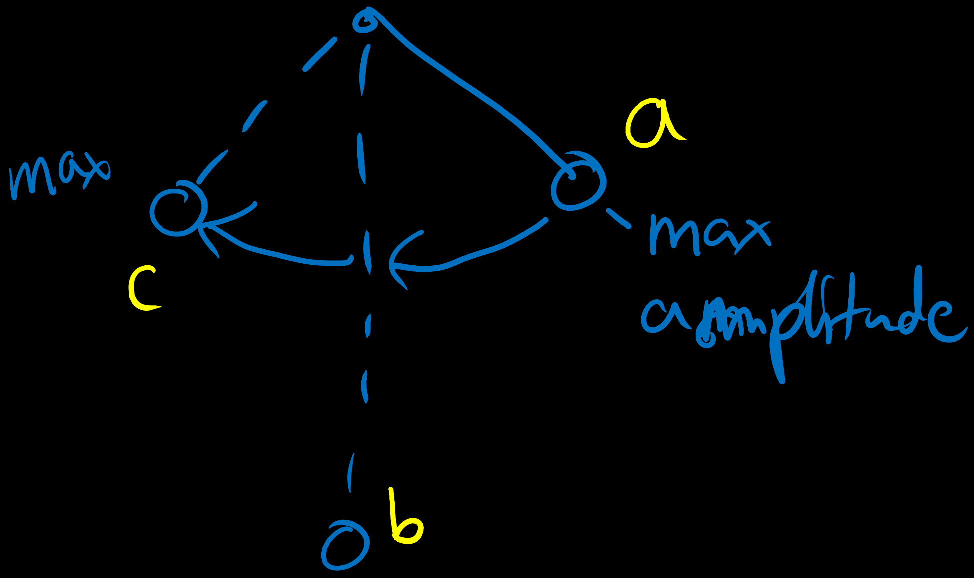
$\longrightarrow \vec{a}$

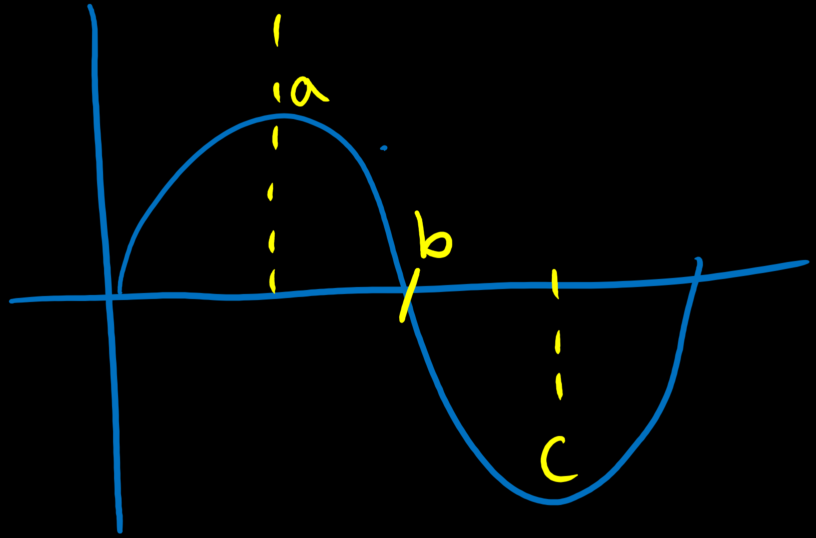
$\longleftarrow \vec{x}$

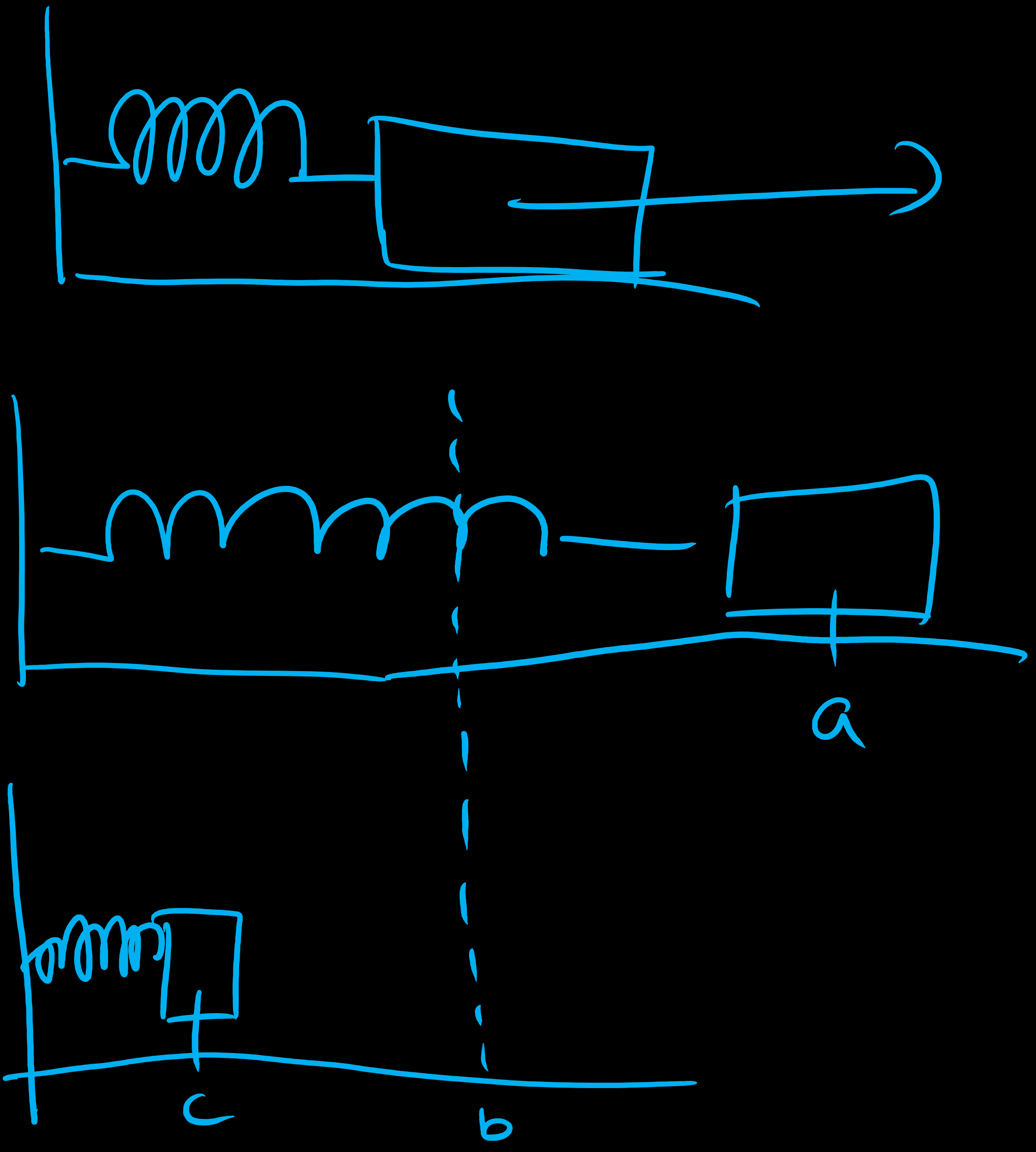




simple pendulum system


max
a
c
max
amplitude
b


a
b
c


a
c
b

Goes & comes back

$\Downarrow$

Periodic function!

$f_1(x) = \sin(x)$

$f_2(x) = \cos(x)$

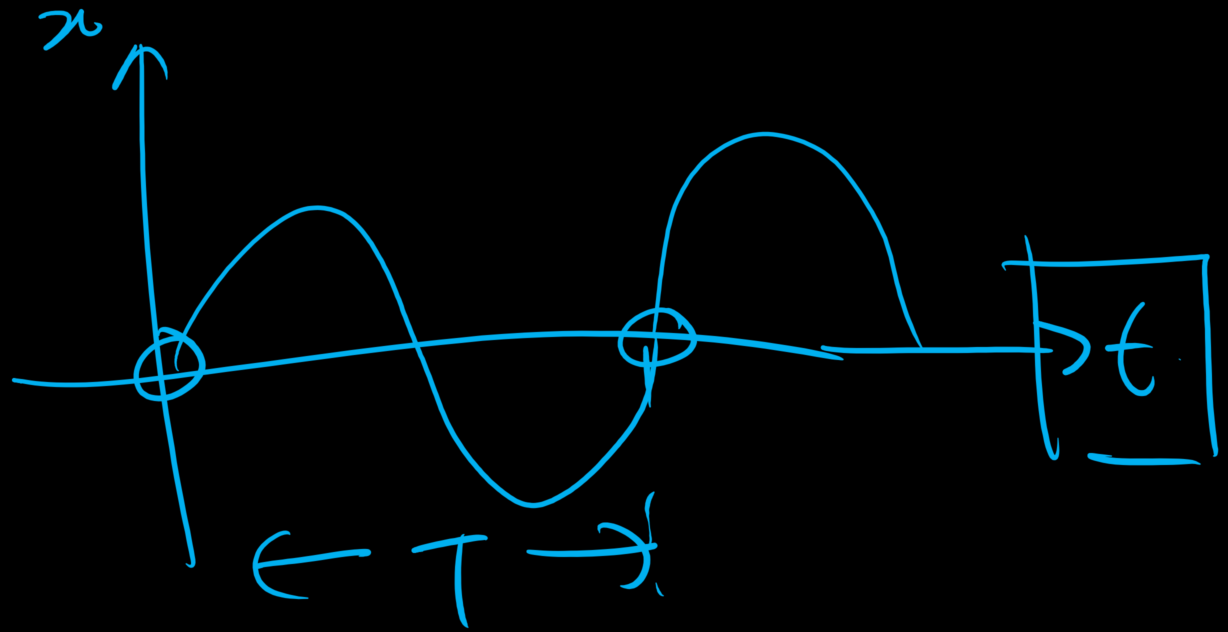
$f_1'(x) = \cos(x)$

$f_2'(x) = -\sin(x)$

$a = \dfrac{d^2x}{dt^2}$

$V = \dfrac{dx}{dt}$

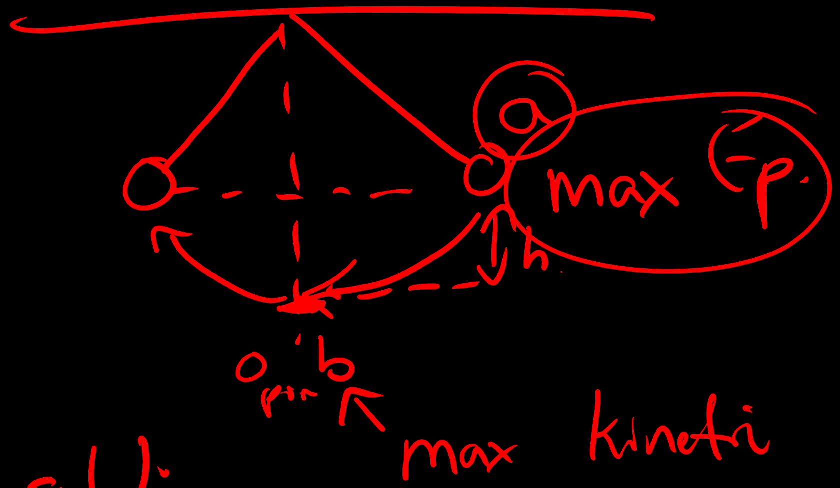
Period:



2 examples

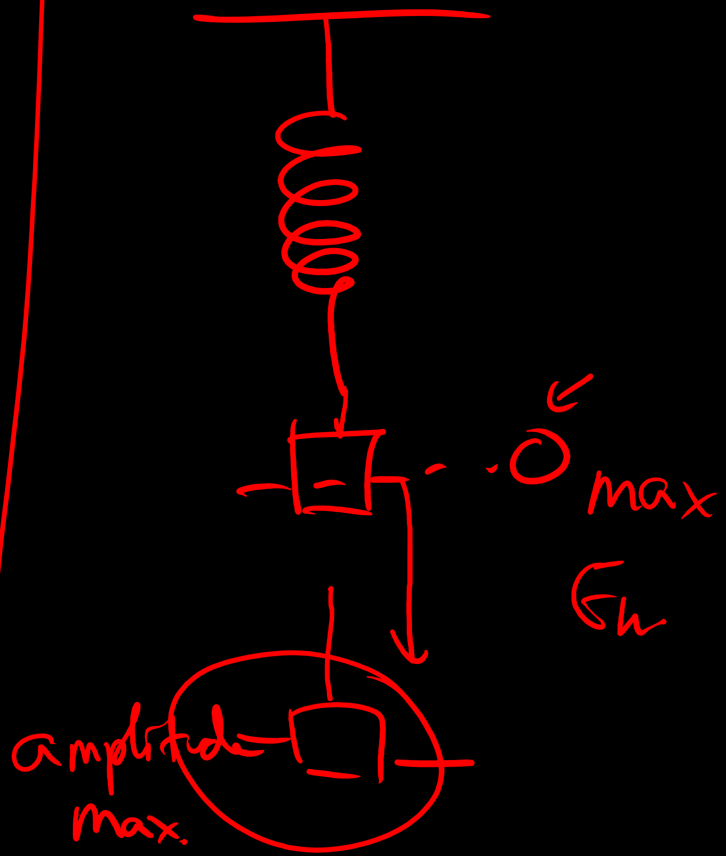
- simple pendulum
- simple spring

Simple pendulum.



$\boxed{Ep} = U.$

Simple spring



SHM

- ~~Ges~~ What is it? $a \propto -x$
- $V, a, E_K, E_p, E_{Total} \Longrightarrow$ calculation & graph

$\underbrace{V, a}_{C2}, \underbrace{E_K, E_p, E_{Total}}_{C5}$

- new things $\rightarrow \omega, T$

ω ← angular frequency

T ← period.

$V(x)$

$a(x)$

$E_k(x)$

$E_p(x)$

$E_T(A)$

Cases studies

$a = -\omega^2 x$ ← general form

apply in case

simple spring

Hooke's Law

$F = -kx$

2nd Law ⇒ $F = ma$

$ma = -kx$

$a = -\boxed{\frac{k}{m}}x$

$a = -\boxed{\omega^2}x$

$\omega^2 = \frac{k}{m} \Rightarrow \omega = \pm\sqrt{\frac{k}{m}}$

simple — spring
— pendulum

$a \propto -x$

SHM

v, a, E_k, E_p, E_T

14 September 2021

Q

Sample Problem 1

1. A 1.75–kg particle moves as function of time as follows:

$$x = 4\cos(1.33t + \pi/5)$$

where distance is measured in metres and time in seconds.

(a) What is the amplitude, frequency, angular frequency, and period of this motion?

(b) What is the equation of the velocity of this particle?

(c) What is the equation of the acceleration of this particle?

(d) What is the spring constant?

(e) At what next time $t > 0$, will the object be:

i. at equilibrium and moving to the right,
ii. at equilibrium and moving to the left,
iii. at maximum amplitude, and
iv. at minimum amplitude.

Sample Problem 1

$\cos(\theta)$

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ii. at equilibrium and moving to the left,
iii. at maximum amplitude, and
iv. at minimum amplitude.

a) $A = 4\text{m}$

freq, $f = 0.219$ Hz

angular f, $\omega = 1.33$ rads^{-1}

f (ω)

$1\text{s} \rightarrow 1.33$ rad

$?\ \text{s} \rightarrow 2\pi$ rad

$4.72\text{s} \rightarrow 2\pi$ rad

1 rev (period) T

$$f = \frac{1}{T} = \frac{1}{4.72}\text{s}^{-1} = 0.21186\text{s}^{-1}$$

$A = 4\text{m}$
$\omega = 1.33$ rads^{-1}
$T = 4.72\text{s}$
$f = 0.21186\text{s}^{-1}$

Sample Problem 1

1. A 1.75–kg particle moves as function of time as follows:

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Generalized Rule (Chain Rule)
$\frac{d}{dx}\sin \mathbf{u} = \cos \mathbf{u}\frac{du}{dx}$
$\frac{d}{dx}\cos \mathbf{u} = -\sin \mathbf{u}\frac{du}{dx}$
$\frac{d}{dx}\tan \mathbf{u} = \sec^2\mathbf{u}\frac{du}{dx}$
$\frac{d}{dx}\cot \mathbf{u} = -\csc^2\mathbf{u}\frac{du}{dx}$
$\frac{d}{dx}\sec \mathbf{u} = \sec \mathbf{u}\tan \mathbf{u}\frac{du}{dx}$
$\frac{d}{dx}\csc \mathbf{u} = -\csc \mathbf{u}\cot \mathbf{u}\frac{du}{dx}$

b) $V = \frac{dx}{dt}$

$x = 4\cos\left(1.33t + \frac{\pi}{5}\right)$

$x = A\cos(\omega t + \phi_0)$

$\frac{dx}{dt} = -\omega A\sin(\omega t + \phi_0)$

$\frac{dx}{dt} = \frac{d}{dt}\left(A\cos(\omega t + \phi_0)\right)$

$= A\frac{d}{dt}\cos(\underbrace{\omega t + \phi_0}_{\text{function}})$

$= A(-\sin(\omega t + \phi_0))\left(\frac{dk}{dt}\right)$

$k = \omega t + \phi_0$

$\frac{dk}{dt} = \omega$

ϕ_0 = phase shift

Sample Problem 1

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i. at equilibrium and moving to the right,
ii. at equilibrium and moving to the left,
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iv. at minimum amplitude.

b) $v = \frac{dx}{dt}$

$= -\omega A \sin(\omega t + \phi_0)$

$\omega = 1.33 \text{ rad s}^{-1}$

$A = 4 \text{ m}$

$\phi = \frac{\pi}{5}$

$v = -(1.33)(4) \sin\left(1.33t + \frac{\pi}{5}\right)$

$= -5.32 \sin\left(1.33t + \frac{\pi}{5}\right)$

Generalized Rule (Chain Rule)
$\frac{d}{dx}\sin \mathbf{u} = \cos \mathbf{u}\,\frac{du}{dx}$
$\frac{d}{dx}\cos \mathbf{u} = -\sin \mathbf{u}\,\frac{du}{dx}$
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$\frac{d}{dx}\sec \mathbf{u} = \sec \mathbf{u}\tan \mathbf{u}\,\frac{du}{dx}$
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i. at equilibrium and moving to the right,

ii. at equilibrium and moving to the left,

iii. at maximum amplitude, and

iv. at minimum amplitude.

c) $a = -\omega^2 x$

$x(t) = 4\cos\left(1.33t + \frac{\pi}{5}\right)$

$a(t) = \underbrace{-(1.33)^2(4)}\cos\left(1.33t + \frac{\pi}{5}\right)$

$a(t) = -7.07\cos\left(1.33t + \frac{\pi}{5}\right)$

d) $F = ma = -kx$

$a = -\boxed{\frac{k}{m}}x$

$a = -\boxed{\omega^2}x$

$\omega^2 = \frac{k}{m}$

$1.33^2 = \frac{k}{1.75}$

$k = 3.0956\ \text{N/m}$

Generalized Rule (Chain Rule)
$\frac{d}{dx}\sin \mathbf{u} = \cos \mathbf{u}\frac{du}{dx}$
$\frac{d}{dx}\cos \mathbf{u} = -\sin \mathbf{u}\frac{du}{dx}$
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$\frac{d}{dx}\cot \mathbf{u} = -\operatorname{cosec}^2 \mathbf{u}\frac{du}{dx}$
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(c) What is the equation of the acceleration of this particle?

(d) What is the spring constant?

(e) At what next time t > 0, will the object be:

$x = 0$ $+v$

i. at equilibrium and moving to the right,

ii. at equilibrium and moving to the left, $-v$

$x=4$ iii. at maximum amplitude, and

iv. at minimum amplitude.

$x=-4$

e) i) & ii)

$0 = \cancel{4}\cos\left(1.33t + \frac{\pi}{5}\right)$

$0 = \cos\left(\underbrace{1.33t + \frac{\pi}{5}}_{\theta_1}\right)$

θ_1? if $\cos(\theta_1) = 0$

$\frac{(2n+1)}{2}$, $n = 0, 1, 2, \ldots$ $n \in \mathbb{R}$

$\theta_1 = \frac{2n+1}{2}\pi$

$V = -\omega A \sin\left(1.33t + \frac{\pi}{5}\right)$

$v > 0 = \cancel{-5.32}\sin\left(1.33t + \frac{\pi}{5}\right)$

$\sin\left(\underbrace{1.33t + \frac{\pi}{5}}\right) > 0$

$n\pi > 0$

$n > 0$

Generalized Rule (Chain Rule)
$\frac{d}{dx}\sin \mathbf{u} = \cos \mathbf{u}\frac{du}{dx}$
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x

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$\frac{d}{dx}\operatorname{cosec} \mathbf{u} = -\operatorname{cosec} \mathbf{u}\cot \mathbf{u}\,\frac{du}{dx}$

$2n+1$, $n = 0, 1, 2, 3 \ldots$

first value

$2n-1$, $n = 1, 2, 3, 4$

$\Theta = \frac{1}{2}\pi = 1.33t + \frac{\pi}{5}$

$\frac{\left(\frac{\pi}{2} - \frac{\pi}{5}\right)}{1.33} = t$

moving to the left

ii) $t = 0.2255\pi$ s $\simeq 0.708$ s

Sample Problem 1

moving to the right

$n \neq 0$

$n = 1$

$$\frac{\left(\frac{3\pi}{2} - \frac{\pi}{5}\right)}{1.33} = t$$

$t = 3.07\,s$ (moving to right)

1. A 1.75−kg particle moves as function of time as follows:

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i. at equilibrium and moving to the right,

ii. at equilibrium and moving to the left,

iii. at maximum amplitude, and

iv. at minimum amplitude.

iii) $\cancel{4} = \cancel{4}\cos\left(1.33t + \frac{\pi}{5}\right)$

$1 = \cos\left(1.33t + \frac{\pi}{5}\right)$

$1.33t + \frac{\pi}{5} = 2n\pi \; ; n = 0, 1, 2, \ldots$

$1.33t + \frac{\pi}{5} = \cancel{0\pi}\ 0$

$t = \dfrac{\left(-\frac{\pi}{5}\right)}{1.33} \; ; < 0$

$1.33t + \frac{\pi}{5} = 2\pi$

$t = \dfrac{2\pi - \frac{\pi}{5}}{1.33} \simeq 4.25\,s$

$-1 = \cos\left(1.33t + \frac{\pi}{5}\right)$

$1.33t + \frac{\pi}{5} = \pi(2n+1)$

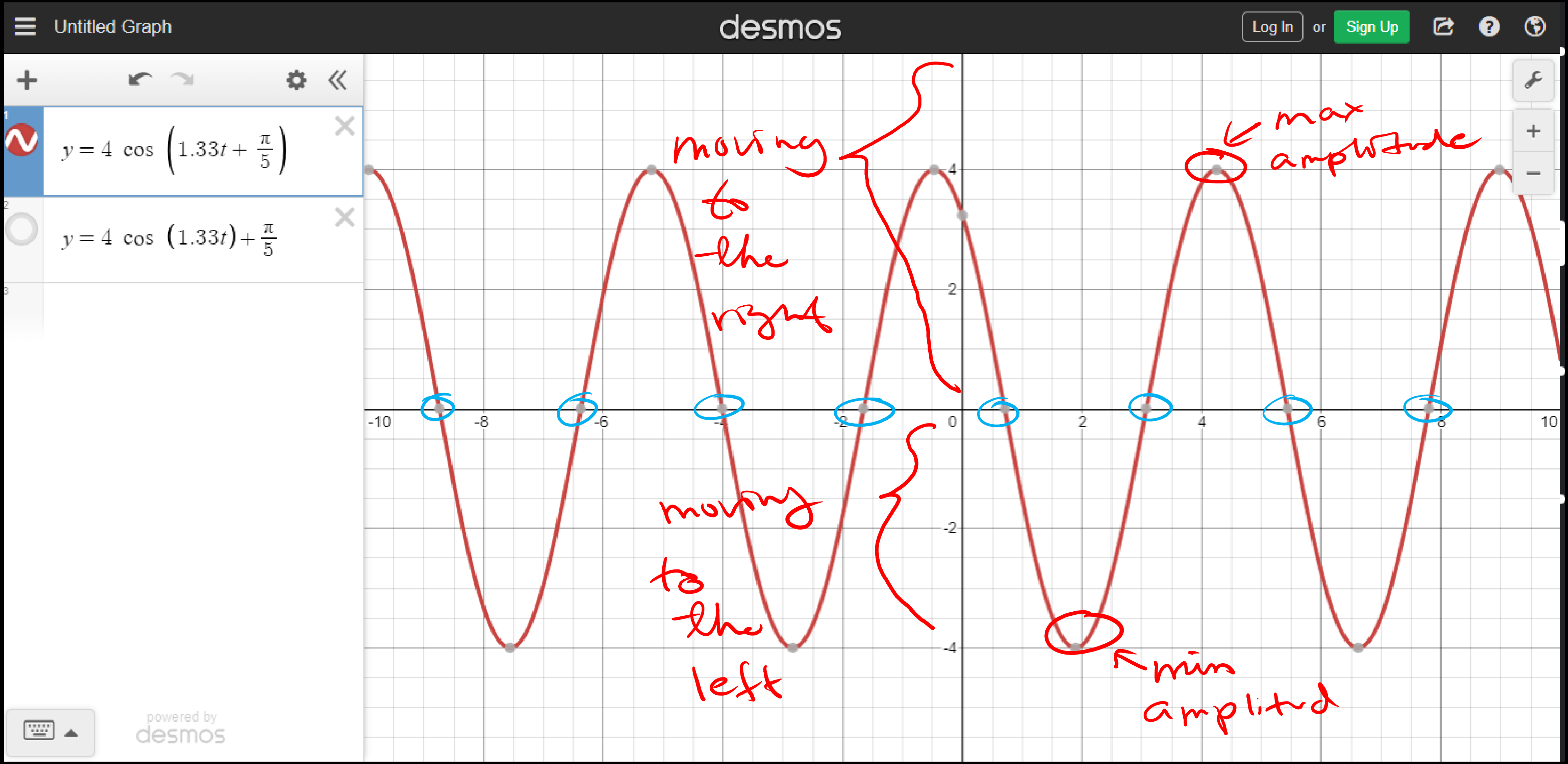
$1.33t + \frac{\pi}{5} = \pi$

$t = \dfrac{\pi - \frac{\pi}{5}}{1.33} \simeq 1.889\,s$

Generalized Rule (Chain Rule)
$\frac{d}{dx}\sin u = \cos u \frac{du}{dx}$
$\frac{d}{dx}\cos u = -\sin u \frac{du}{dx}$
$\frac{d}{dx}\tan u = \sec^2 u \frac{du}{dx}$
$\frac{d}{dx}\cot u = -\operatorname{cosec}^2 u \frac{du}{dx}$
$\frac{d}{dx}\sec u = \sec u \tan u \frac{du}{dx}$
$\frac{d}{dx}\operatorname{cosec} u = -\operatorname{cosec} u \cot u \frac{du}{dx}$

Sample Problem 1

equilibrium $\Rightarrow x_0 = 0$



Sample Problem 2

A horizontal spring with k = 200N/m has an attached mass of 0.150 kg. It is stretched and released. As the mass passes through the equilibrium point, its speed is 5.25 m/s. What was the amplitude of the motion?

Atirah

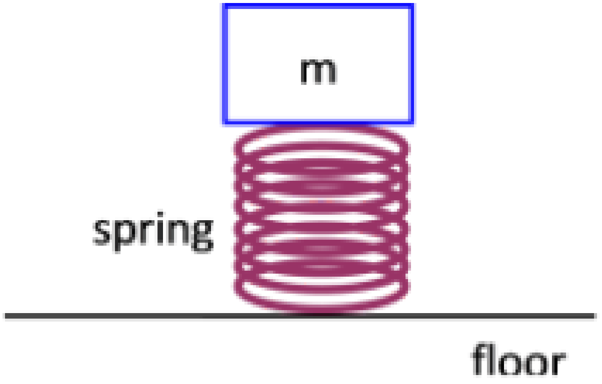
Jessured

=)

Discuss tomorrow ☺

Sample Problem 3

A stiff spring k = 400 N/m has be attached to the floor vertically. A mass of 6.00 kg is placed on top of the spring as shown below and it finds a new equilibrium point. If the block is pressed downward and released it oscillates. If the compression is too big, however, the block will lose contact with the spring at the maximum vertical extension. Draw a free body diagram and find that extension at which the block loses contact with the spring.



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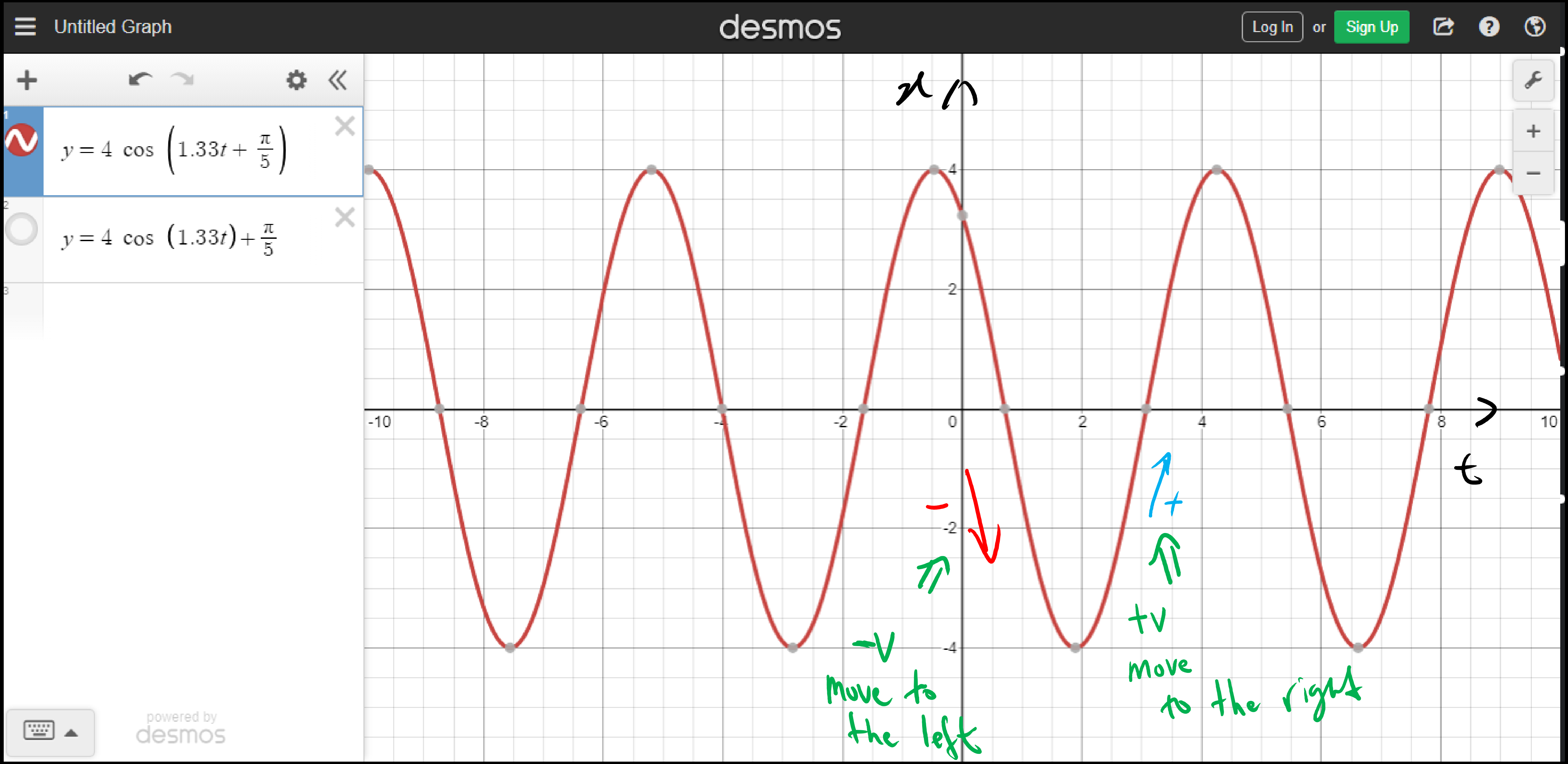
Discuss tomorrow ☺

Thank you!

15 September 2021

Sample Problem 1

Correct one.



Sample Problem 2

A horizontal spring with k = 200N/m has an attached mass of 0.150 kg. It is stretched and released. As the mass passes through the equilibrium point, its speed is 5.25 m/s. What was the amplitude of the motion?

Sample Problem 2

$k = 200\,N/m$
$v = 5.25\,m/s$
$m = 0.15\,kg$

2nd law (1)

Hooke's law

$F = ma$, $F = -kx$

$-kx = ma$

$a = -\frac{kx}{m}$ —(1)

compare

$a = -\omega^2 x$ —(2) (2)

subs (1) into (2)

$-\omega^2 x = -\frac{kx}{m}$

$\omega = \sqrt{\frac{k}{m}}$

$\omega = \sqrt{\frac{200}{0.15}}$

$\omega = 36.51\,rad\,s^{-1}$

(3) solve for ω

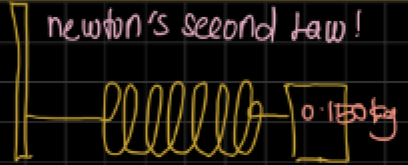
eqn (4)

$v(max) = \omega A$

$5.25 = 36.51 A$

$A = 0.144m$

newton's second law!



comparison

$F = ma$

$ma = -kx$

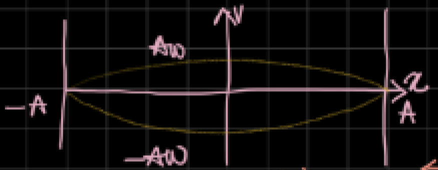
$a = -\frac{k}{m}x$

velocity of particle,

def $v = \frac{dx}{dt}$

eqn $v = A\omega\cos(\omega t + \phi)$

$v = \omega\sqrt{A^2 - x^2}$



condition when $x = 0$,

its maximum velocity, $V_{max} = \omega A$

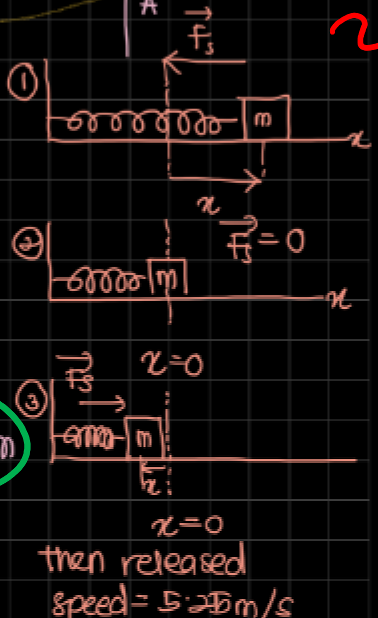
conve def SHM, $a = -\omega^2 x$

Hooke's law $\omega^2 = \boxed{\frac{k}{m}}$, $\omega = \sqrt{\frac{k}{m}}$

amplitude, $A = \frac{V}{\omega} = \frac{V}{\sqrt{\frac{k}{m}}}$

Calculation $A = \frac{5.25}{\sqrt{\frac{200}{0.150}}} \approx 0.1438m$

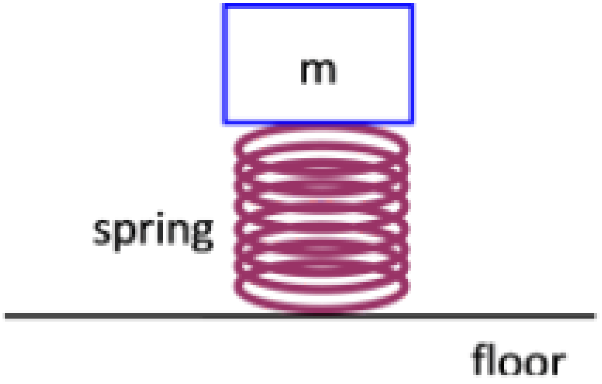
Diagrams



Sample Problem 3

x = spring max compression = amplitude at which the block loses contact

A stiff spring k = 400 N/m has be attached to the floor vertically. A mass of 6.00 kg is placed on top of the spring as shown below and it finds a new equilibrium point. If the block is pressed downward and released it oscillates. If the compression is too big, however, the block will lose contact with the spring at the maximum vertical extension. Draw a free body diagram and find that extension at which the block loses contact with the spring.



N

W

$\downarrow +y$

2nd Law: $F = ma$

law

Hooke' Law: $F = -kx$

$m = 6\,kg$

$\boxed{a = -\omega^2 x}$ ← def (SHM)

$\sum F_y = -m\omega^2 \underbrace{x}_{a}$

condition

the moment of contact loss $\Rightarrow N = 0$

$-mg = -m\omega^2 x$

$x = +\frac{g}{\omega^2}$ ①

$\omega = \sqrt{\frac{k}{m}} \Rightarrow \omega^2 = \frac{k}{m}$ ②

② into ①

$x = +\frac{9.81}{\left(\frac{400}{6}\right)} \simeq +0.14715\,m$

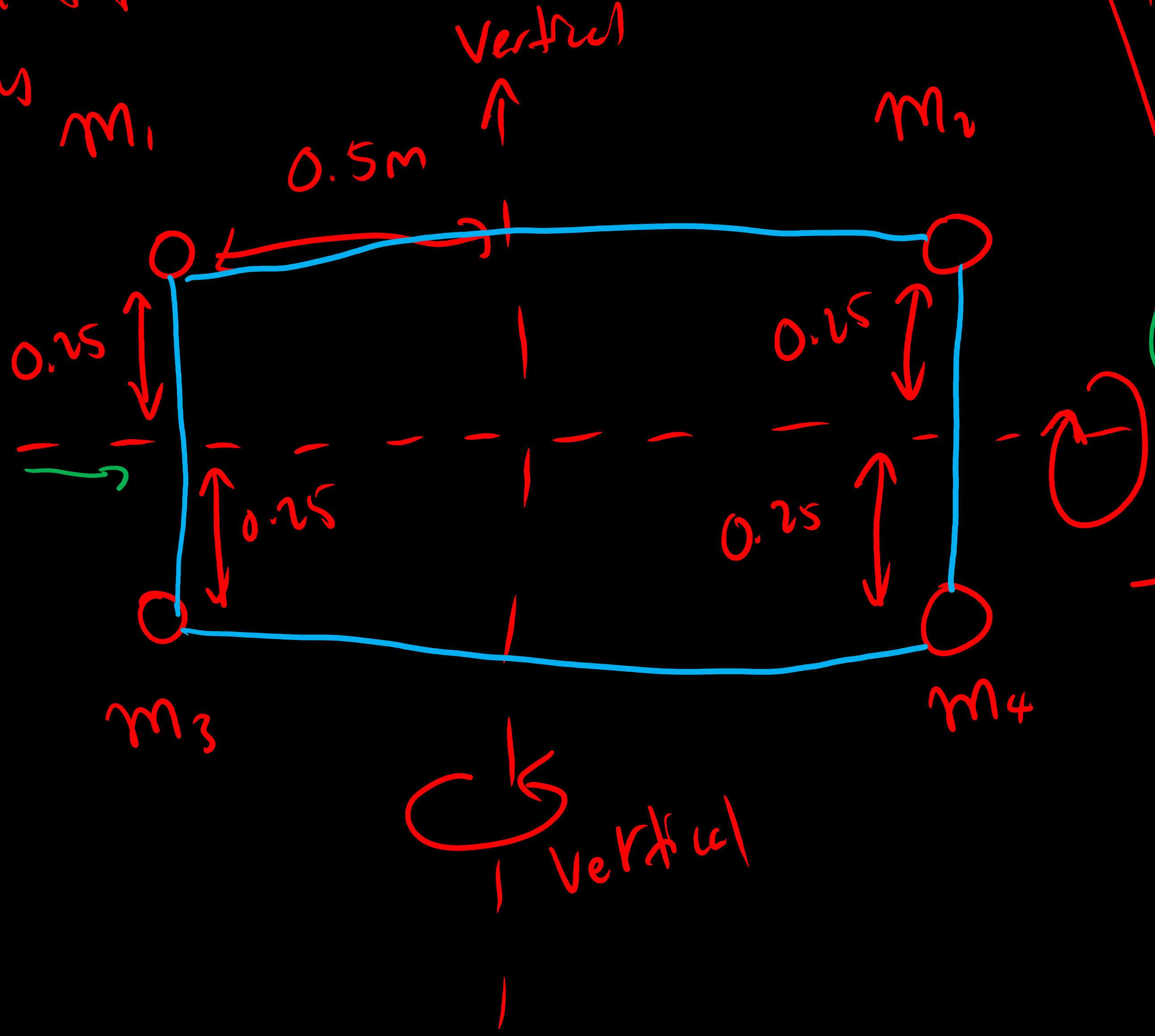
Homework

Exercise 1.6

A massless spring attached to a wall lies on a frictionless table. It has a block of mass 2 kg attached to one end. Initially the block is at rest. Another block, also of mass 2 kg is sliding along on the tabletop with a speed of 8 m/s. At time $t = 0$, the moving block collides with the block on the spring. The two stick together and oscillate back and forth. If the spring constant is 16 N/m, find an expression $x(t)$ which describes the motion of the two blocks that are stuck together.

Friday discuss – random name pick

8.3 Rotational dynamics



point objects

$$I = \sum m r^2$$ ← point masses

Horizontal

$$I = m_1 (0.25)^2 + m_2 \cancel{0.5} (0.25)^2 + m_3 (0.25)^2 + m_4 (0.25)^2$$

Thank you!

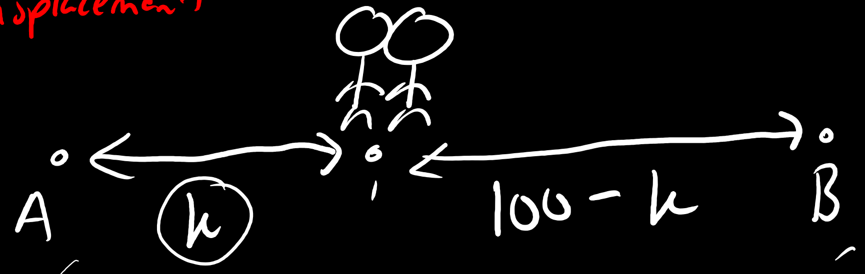
Rasulan, S.
+60105520080
KMSw

16 September 2021

1. Chapter 2

Two people starts running straight towards each other from points 100m apart. One of them runs at $6ms^{-1}$ and the other runs at $9ms^{-1}$. Where do they meet?

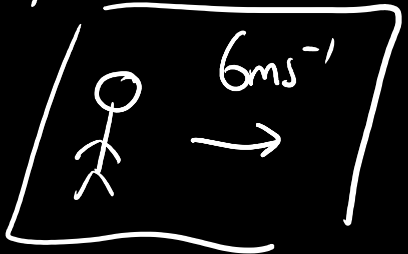
displacement



before

after

x, v, a



2nd term ~ 0

$\vec{a} = 0$

$\Delta \vec{V} = 0$

$s = ut + \cancel{\frac{1}{2}at^2}$

$s = ut$

$S_{gf} = V_{gf}(t)$

$k = 6(t)$

$t = \frac{k}{6} = \frac{100-k}{9}$

$9k = 600 - 6k$

$S_a = V_a(t)$

$100 - k = 9(t)$

$15k = 600$

$k = 40m$

{They meet 40m from point A.}

2. Chapter 3

Two identical balls collide head on. Their initial velocities are $0.75 ms^{-1}$ and $-0.43 ms^{-1}$ respectively. If the collision is perfectly elastic, calculate the final velocity of each ball.

$\rightarrow +x$

$m_1 = m_2 = m$

perfectly elastic $\Rightarrow \Delta E_k = 0$

2 eqns. $\begin{cases} \Delta p = 0 \\ \Delta E_k = 0 \end{cases}$

$$\Delta p = 0 : \overset{p_i}{\cancel{m}(u_1 + u_2)} = \overset{p_f}{\cancel{m}(v_1 + v_2)}$$

$$u_1 + u_2 = v_1 + v_2$$

$$0.75 - 0.43 = \boxed{v_1 + v_2 = 0.32 ms^{-1}} \quad ①$$

$$\Delta E_k = 0 : \cancel{\tfrac{1}{2}m} u_1^2 + \cancel{\tfrac{1}{2}m} u_2^2 = \cancel{\tfrac{1}{2}m}(v_1^2 + v_2^2)$$

$$0.75^2 + (-0.43)^2 = v_1^2 + v_2^2$$

$$\boxed{v_1^2 + v_2^2 = 0.7474 m^2 s^{-2}} \quad ②$$

2. Chapter 3

Two identical balls collide head on. Their initial velocities are $0.75ms^{-1}$ and $-0.43ms^{-1}$ respectively. If the collision is perfectly elastic, calculate the final velocity of each ball.

$V_1 + V_2 = 0.32$

$V_1^2 + V_2^2 = 0.7474$

$V_1 = 0.32 - V_2$

$(0.32 - V_2)^2 + V_2^2 = 0.7474$

$(0.32 - V_2)(0.32 - V_2) + V_2^2 = 0.7474$

$0.1024 \underbrace{- 0.32V_2 - 0.32V_2} + V_2^2 + V_2^2 = 0.7474$

$0.1024 - 0.64V_2 + 2V_2^2 = 0.7474$

$2V_2^2 - 0.64V_2 - 0.645 = 0$

$V_2 = \{0.75, -0.43\}$

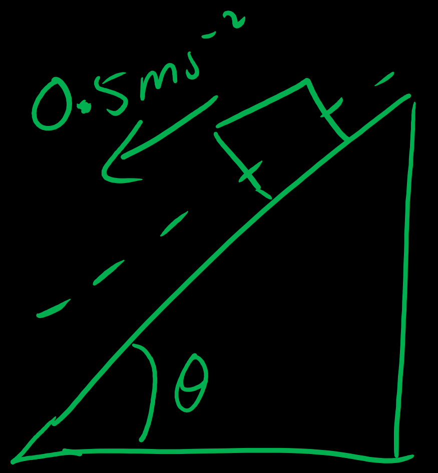
$V_1 = \{0.32 - 0.75, 0.32 + 0.43\}$

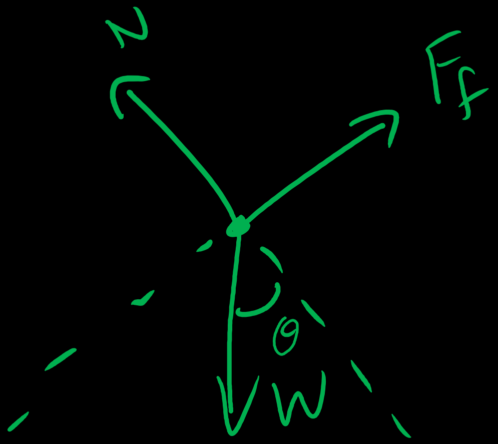
$V_1 = \{-0.43, \cancel{0.75}\}$

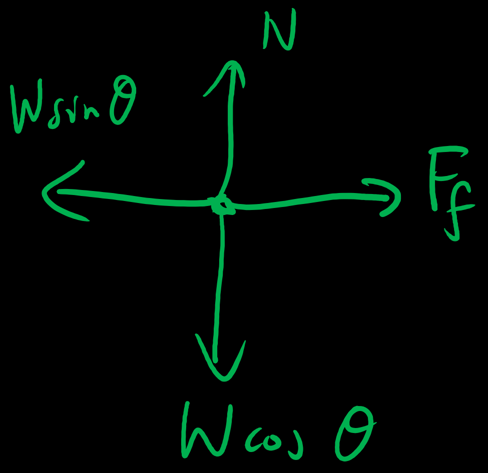
$V_2 = \{0.75, \cancel{-0.43}\}$

3. Chapter 4

A 10-kg block is released on an incline plane and accelerates down at $0.5ms^{-2}$. Find the frictional force impeding its motion and the coefficient of friction in this situation.







$$\boxed{\sum F_x} = W\sin\theta - F_f = ma_x$$

$$F_f = mg\sin\theta - ma_x \quad (1)$$

$$\boxed{F_f = 98.1\sin\theta - 5}$$

$$F_f = \mu N \; ; \; N = W\cos\theta \quad (2)$$

$$\mu = \frac{F_f}{N} \quad (3)$$

(1) & (2) into (3)

$$\mu = \frac{mg\sin\theta - ma_x}{mg\cos\theta}$$

$$\mu = \frac{9.81\sin\theta - 0.5}{9.81\cos\theta} \quad (4)$$

$$\boxed{\mu = \tan\theta - \frac{0.5}{9.81\cos\theta}}$$

4. Chapter 5

An engine expends 45hp in propelling a car along a level track at $15ms^{-1}$. How large is the total retarding force acting on the car?

power

$P = 45hp$

$V = 15ms^{-1}$

F_r ?

$\Delta V = 0$

$a = 0$

$1hp = 746W$

$P = F.v$

$F = P/v$

F_{engine} $F_{retarding}$ F_{push} $F_{retarding}$

$$\sum F_x = F_{engine} - F_{retarding}$$

$$m a_x = F_{engine} - F_r$$

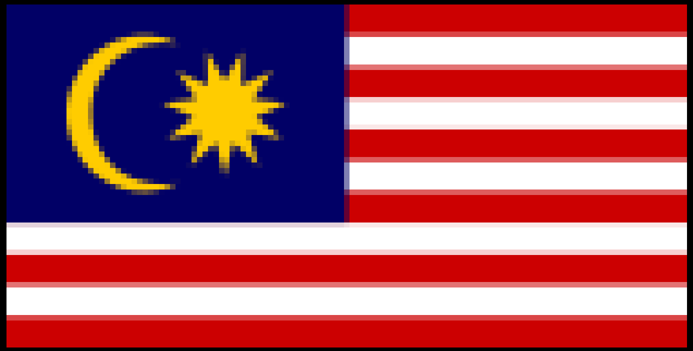
$$0$$

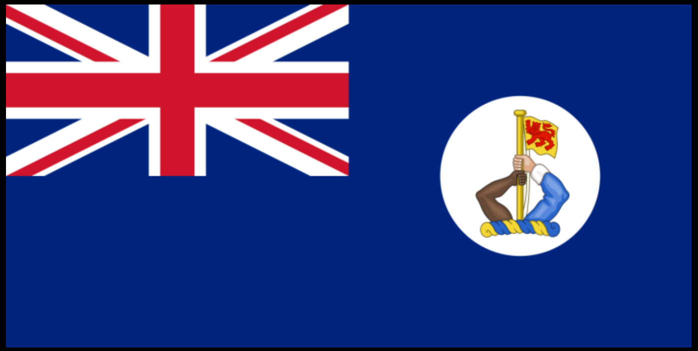
$$F_{engine} = F_r$$

$$\frac{(45)(746W)}{15} = F_r$$

$$\boxed{F_r = 2238N}$$

THANK YOU!
HAPPY MALAYSIA DAY!





17 September 2021

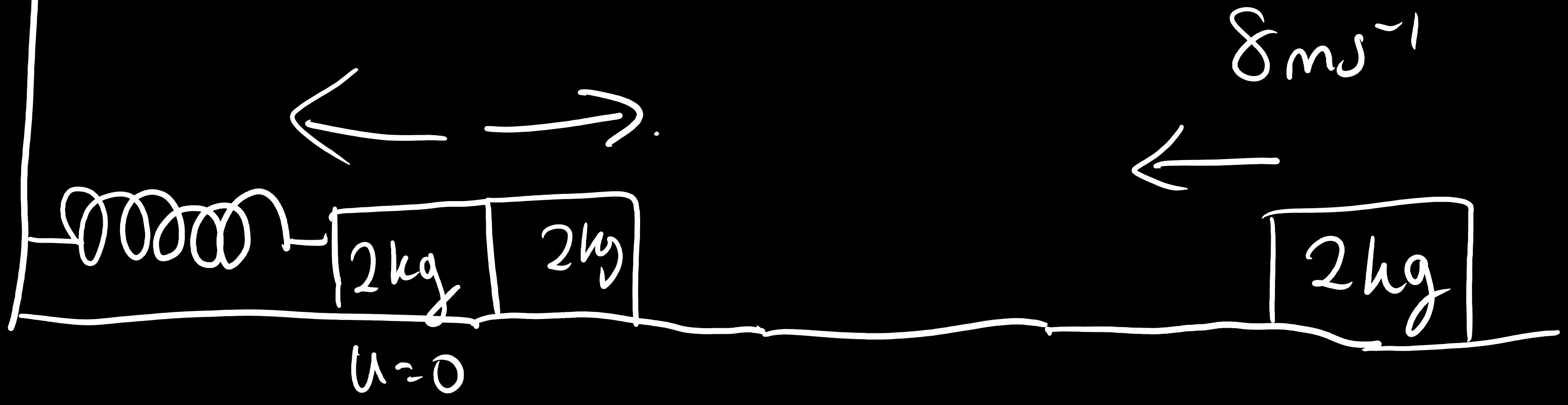
Sample Problem 1

Exercise 1.6

A massless spring attached to a wall lies on a frictionless table. It has a block of mass 2 kg attached to one end. Initially the block is at rest. Another block, also of mass 2 kg is sliding along on the tabletop with a speed of 8 m/s. At time $t = 0$, the moving block collides with the block on the spring. The two stick together and oscillate back and forth. If the spring constant is 16 N/m, find an expression $x(t)$ which describes the motion of the two blocks that are stuck together.

$k = 16 \, N m^{-1}$

GE: $x(t) = A \sin(\omega t + \phi)$



Aisyah airiza's

Exercise 1.6
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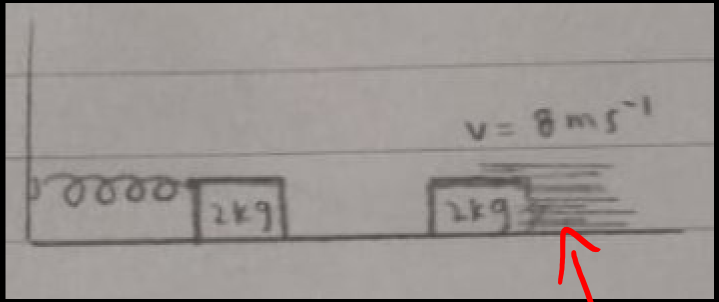


moving !

$$\boxed{w} = \sqrt{\frac{k}{m}}$$

$$= \sqrt{\frac{16}{4}}$$

$$= 2$$

Hooke's Law = $F = -kx$

Newton' 2nd Law = $F = ma$

$$ma = -kx$$

$$a = \frac{-kx}{m}$$

$$a = -w^2 x$$

$$\frac{-k\cancel{x}}{m} = -w^2 \cancel{x} \qquad w^2 = \frac{k}{m}$$

$$w = \sqrt{\frac{k}{m}}$$

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$$

$$2(0) + 2(8) = (2+2) v$$

$$16 = 4v$$

$$v = 4 ms^{-1}$$

Amplitude, $\boxed{A = \frac{v}{\omega}}$

$$= \frac{4}{2}$$

$$= 2 \text{ m}$$

$$x(t) = A \sin(\omega t + \text{Ø})$$

$$= 2 \sin(2t + \text{Ø})$$

how can you find this

Layvia's

Exercise 1.6

A massless spring attached to a wall lies on a frictionless table. It has a block of mass 2 kg attached to one end. Initially the block is at rest. Another block, also of mass 2 kg is sliding along on the tabletop with a speed of 8 m/s. At time $t = 0$, the moving block collides with the block on the spring. The two stick together and oscillate back and forth. If the spring constant is 16 N/m, find an expression $x(t)$ which describes the motion of the two blocks that are stuck together.

A $m = 2kg$

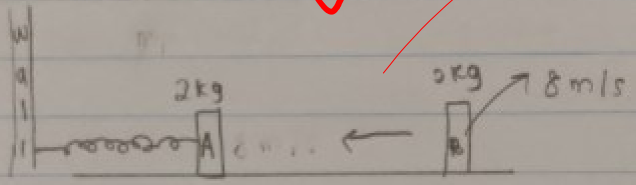
B $m = 2kg$

$v = 8\ m/s$

acceleration, $a = 0$

velocity, $v = 0$

↳ doesn't change.

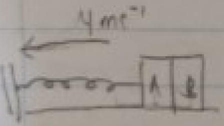


$$(M_A + M_B)v_f = M_A v_0$$

conservation of momentum

$$(2+2)v_f = 2(8)$$

$$v_f = \frac{16}{4}$$



$$v_f = 4ms^{-1}$$

Hooke's Law

$$\omega = \sqrt{\frac{k}{m}}$$

$$= \sqrt{\frac{16}{4}}$$

General equation of SHM

$$x(t) = A \sin(\omega t \pm \phi)$$

general equation

$$x(t) = \frac{v}{\omega} \sin \omega t$$

$$= \frac{4}{2} \sin 2t$$

$$x(t) = 2 \sin 2t \ ?$$

$$\boxed{A} = \frac{v}{\omega} \ ?$$

$$\phi = 0 \ ?$$

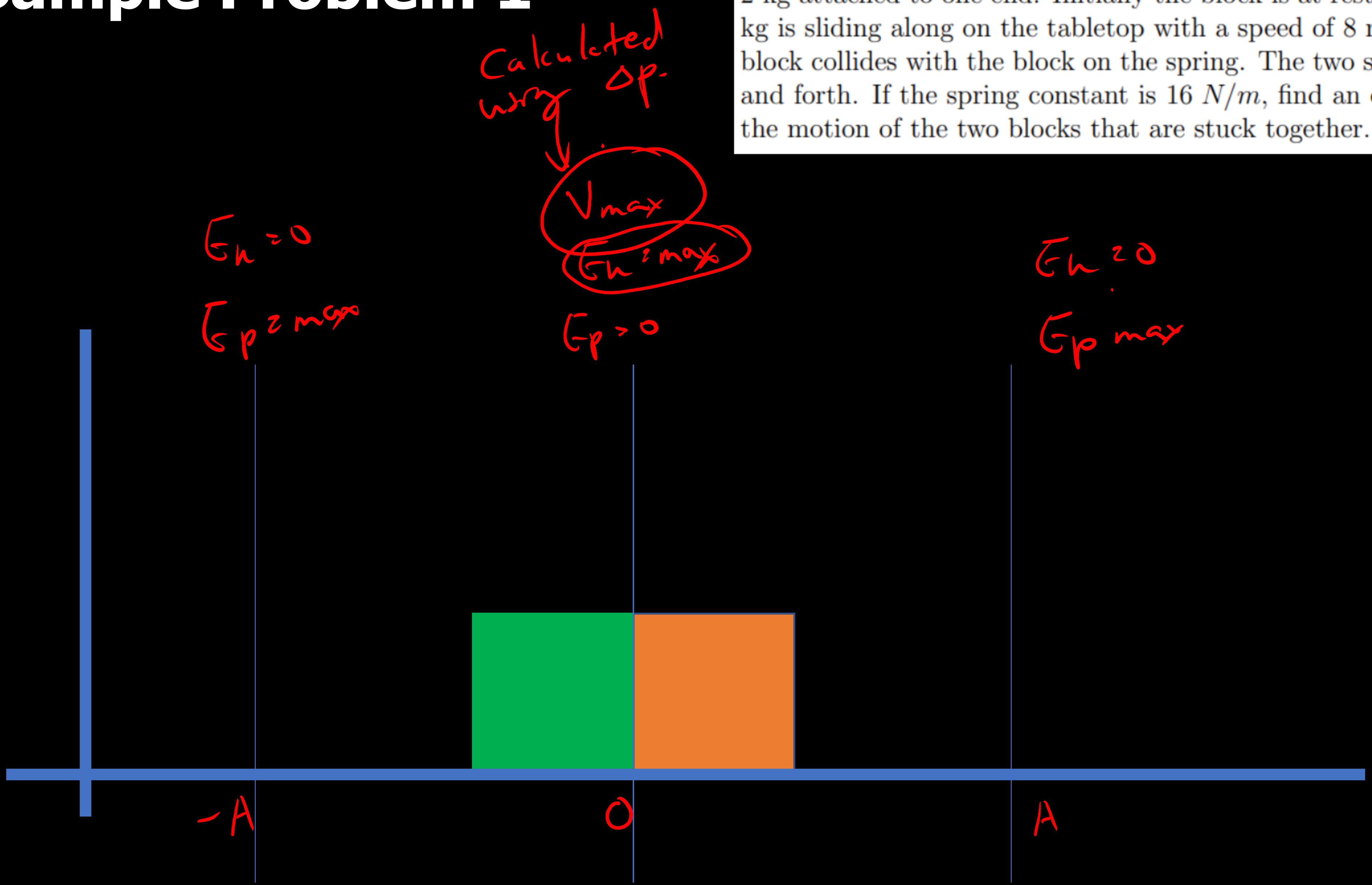
$$\boxed{V = \omega A}$$

$\phi = 0$ because at $t = 0$, $x = 0$.

Sample Problem 1

Exercise 1.6

A massless spring attached to a wall lies on a frictionless table. It has a block of mass 2 kg attached to one end. Initially the block is at rest. Another block, also of mass 2 kg is sliding along on the tabletop with a speed of 8 m/s. At time $t = 0$, the moving block collides with the block on the spring. The two stick together and oscillate back and forth. If the spring constant is 16 N/m, find an expression $x(t)$ which describes the motion of the two blocks that are stuck together.



Problem 2

Joan has two pendula, one has a length of 1 meter, and the other one is longer. She sets them both swinging at the same time. After the 1 meter pendulum has completed 12 oscillations, the longer one has only completed 11. How long is the longer pendulum?

$l_1 = 1\,m$

$l_2 > l_1$

$\underbrace{t_2 > t_1}_{}$

\# of oscillation

$\left(T_i = 2\pi\sqrt{\frac{l_i}{g}}\right)^2$ ← 1 oscillation

$\frac{T_1}{T_2} = \frac{N_2}{N_1} = \frac{11}{12}$

$\boxed{t_i = T_i N_i}$

number of oscillation

period

$\downarrow T_i,\ \uparrow N$

$T_i^2 = 4\pi^2\left(\frac{l_i}{g}\right)$

changes | constant

$\frac{T_i^2}{l_i} = \boxed{\frac{4\pi^2}{g}}$

$\frac{T_1^2}{l_1} = \frac{T_2^2}{l_2}$

$\frac{T_1^2}{T_2^2} = \frac{l_1}{l_2} = \frac{N_2^2}{N_1^2}$

$l_1 = \left(\frac{N_1}{N_2}\right)^2 l_1 = \left(\frac{12}{11}\right)^2(1) \approx 1.19$

Thank you!

21st September 2021
Chapter 10 Lecture

Time allocation:
2.5h (Lecture) + 10h (Tutorial)
Learning Outcomes:

1. Define wavelength, λ, and wave number, k.
2. Solve problems related to the equation of progressive wave, $y(x,t) = Asin(\omega t \pm kx)$
3. Discuss and use the particle vibrational velocity and wave propagation velocity (group velocity)
4. Discuss the graphs of:
   - displacement-time, $y - t$
   - displacement-distance, $y - x$.
5. State the principle of superposition of waves for constructive and destructive interferences.
6. Use the standing wave equation, $y = Acos(kx)sin(\omega t)$
7. Discuss progressive and standing wave.
8. Define and use sound intensity
9. Discuss the dependence of intensity on amplitude and distance from a point source by using graphical illustrations.
10. Solve problems related to the fundamental and overtone frequencies for:
    - stretched string
    - air columns (open and closed)
11. Use wave speed in a stretched string, $v = \sqrt{\frac{T}{\mu}}$.
12. State Doppler effect for sound waves.
13. Apply Doppler effect equation, $f_{apparent} = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$, for relative motion between source and observer. Limit to stationary observer and moving source, and vice versa.

characteristic of wave

(y is a function of x & t.)

1. Define wavelength, λ, and wave number, k.

2. Solve problems related to the equation of progressive wave, $y(x, t) = A sin(\omega t \pm kx)$

3. Discuss and use the particle vibrational velocity and wave propagation velocity (group velocity)

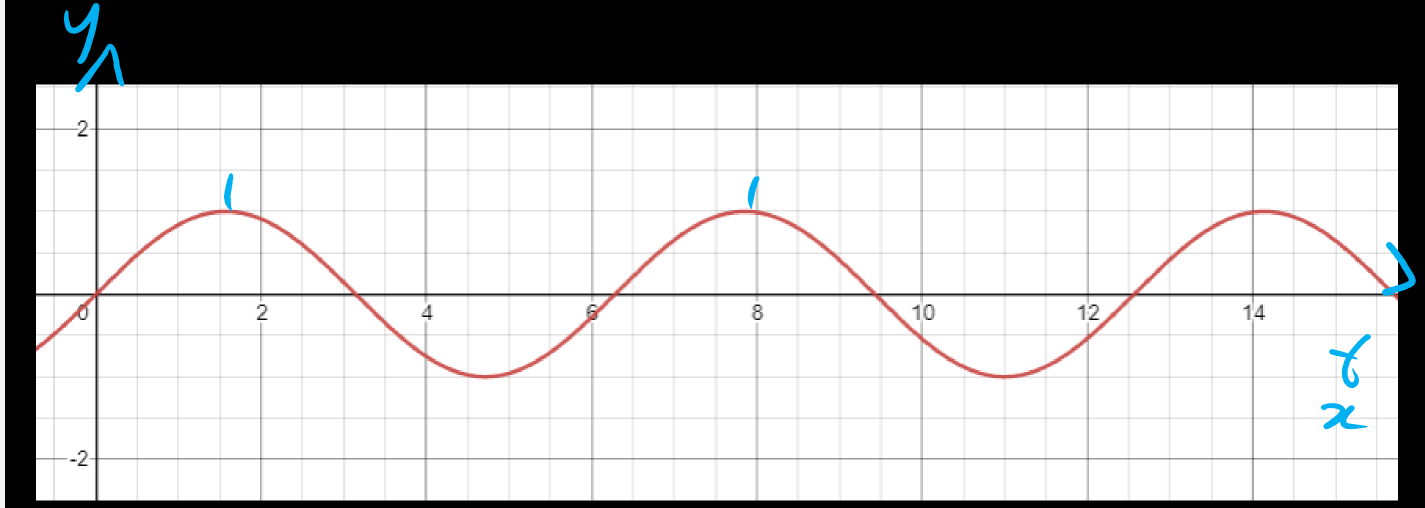
4. Discuss the graphs of:

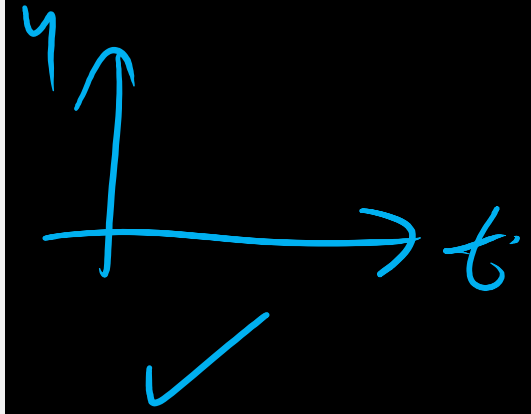
   - displacement-time, $y - t$
   - displacement-distance, $y - x$.

5. State the principle of superposition of waves for constructive and destructive interferences. = Campur.

6. Use the standing wave equation, $y = A cos(kx) sin(\omega t)$

7. Discuss progressive and standing wave.





8. Define and use sound intensity

9. Discuss the dependence of intensity on amplitude and distance from a point source by using graphical illustrations.

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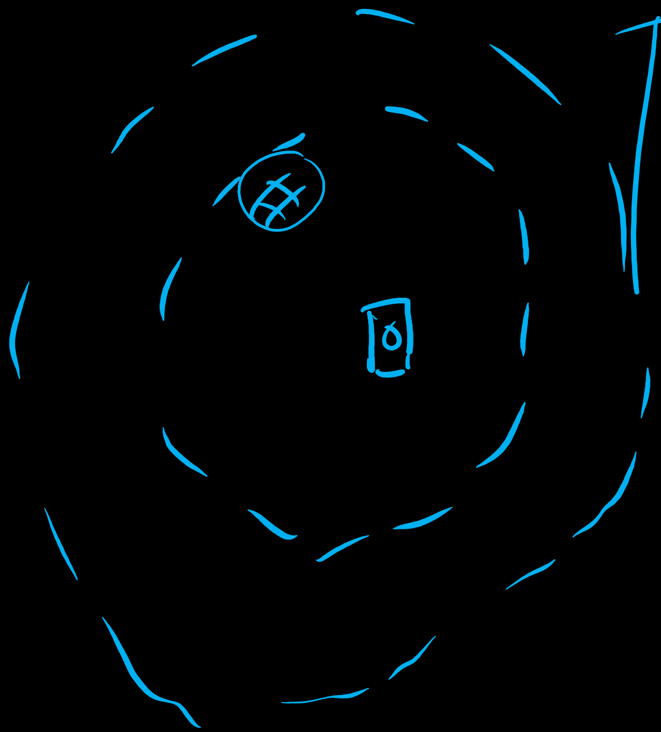
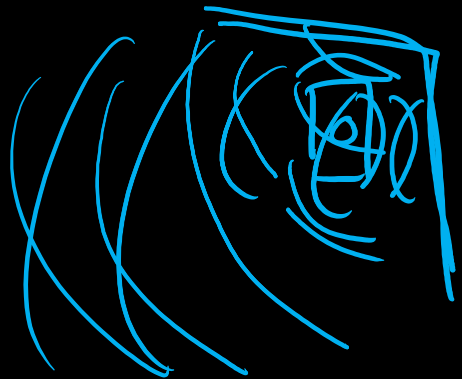
$4\pi r^2$



$$\boxed{I = \frac{P}{4\pi r^2}}$$



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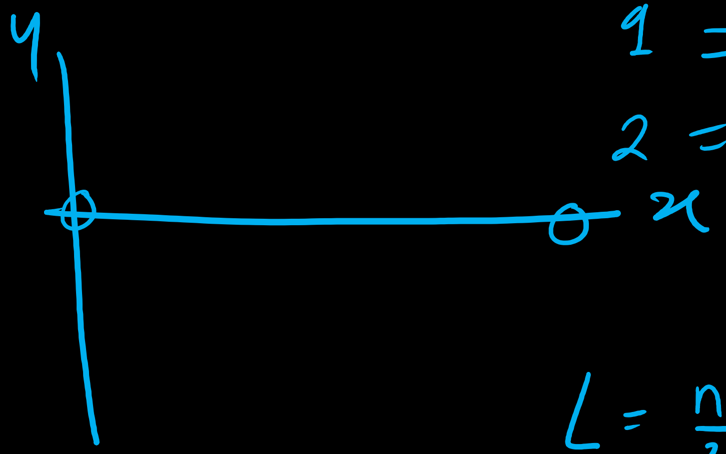
Stretched



Harmonic

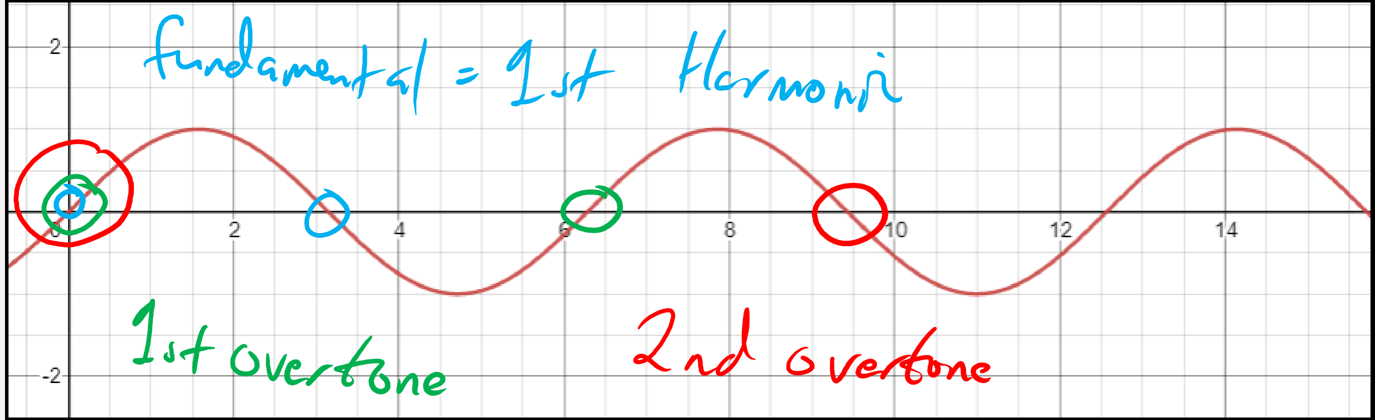
$1 \Rightarrow \frac{1}{2}\lambda$

$2 \Rightarrow 1\lambda = \frac{2}{2}\lambda$

$3 \Rightarrow \frac{3}{2}\lambda$

$4 \Rightarrow 2\lambda = \frac{4}{2}\lambda$

$L = \frac{n}{2}\lambda$; $f = \frac{v}{\lambda}$



= 2nd Harmonic

= 3rd Harmonic

$$\left[f_n = \frac{nv}{2L} ; \boxed{v^2 = \frac{T}{\mu}} ; \mu = \frac{m}{L} \right]$$

8. Define and use sound intensity

9. Discuss the dependence of intensity on amplitude and distance from a point source by using graphical illustrations.

10. Solve problems related to the fundamental and overtone frequencies for:

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    - air columns (open and closed)

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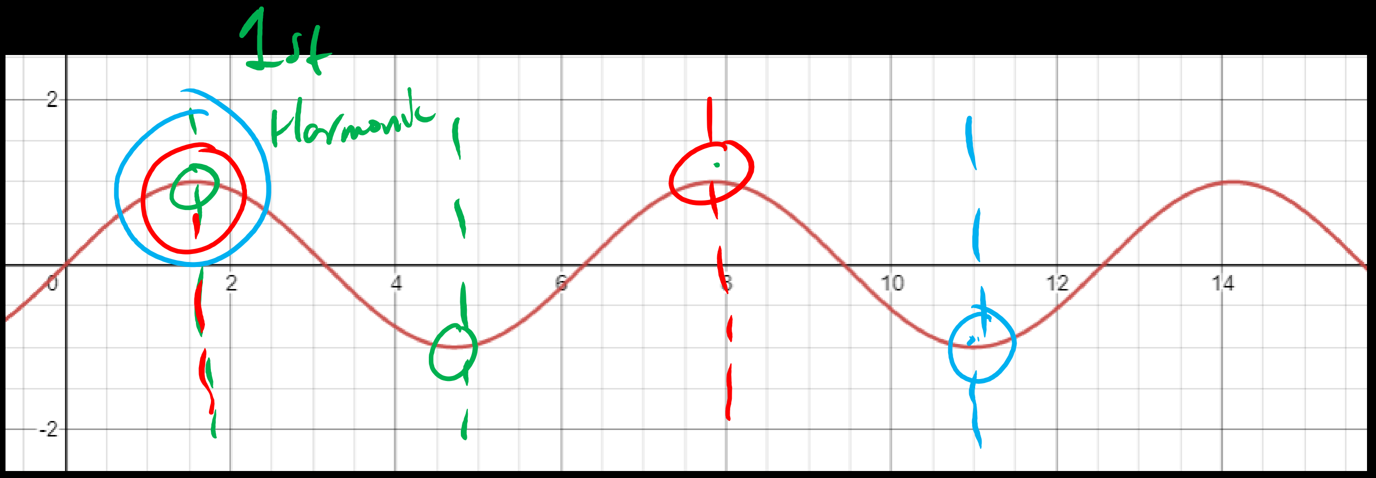

Open tube 2nd Harmonic 3rd Harmonic

AN AN

L

nth Harmonic	λ
1st	$\frac{1}{2}\lambda$
2nd	$1\lambda = \frac{2}{2}\lambda$
3rd.	$\frac{3}{2}\lambda$

$$f_n = \frac{nv}{2L}.$$

length of air column

8. Define and use sound intensity

9. Discuss the dependence of intensity on amplitude and distance from a point source by using graphical illustrations.

10. Solve problems related to the fundamental and overtone frequencies for:

    - stretched string
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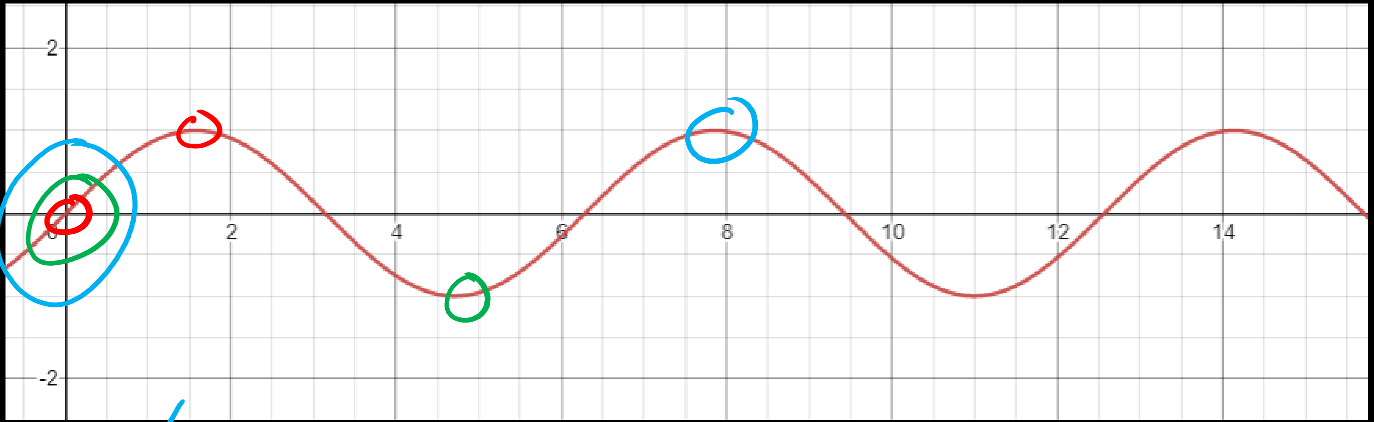
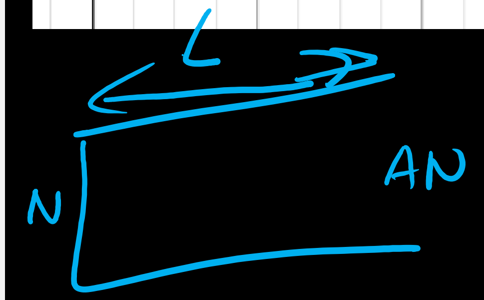




nth har	λ
1st	$\frac{1}{4}\lambda$
2nd	$\frac{3}{4}\lambda$
3rd	$\frac{5}{4}\lambda$

$L = \frac{n}{4}\lambda$; $n = 1, 3, 5, 7 \ldots$

$L = \frac{(2n+1)}{4}\lambda$; $n = 0, 1, 2, 3, 4, 5$

$f_n = \frac{(2n+1)v}{4L}$

8. Define and use sound intensity

9. Discuss the dependence of intensity on amplitude and distance from a point source by using graphical illustrations.

10. Solve problems related to the fundamental and overtone frequencies for:

    - stretched string
    - air columns (open and closed)

11. Use wave speed in a stretched string, $v = \sqrt{\frac{T}{\mu}}$.

12. State Doppler effect for sound waves.

13. Apply Doppler effect equation, $f_{apparent} = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$, for relative motion between source and observer. Limit to stationary observer and moving source, and vice versa.

Doppler effect.

towards ⇒ higher freq

away ⇒ lower freq

Thank you!

22 September 2021

Sample Problem 1

← left

ada soalan?

1. A progressive wave is represented by the equation

$$y = 5sin(2\pi t + \frac{\pi}{2}x)$$ ← wave equations

Where y and x are in centimetres and t is in seconds. Determine the amplitude, angular frequency, wavelength, period, frequency, wave speed and direction of motion.

in the -ve x direction

Quantities ↓

A?
ω?
λ?
T?
f?
v?

$A = 5cm$

$\omega = 2\pi \ rads^{-1}$

k has unit of $rad\,cm^{-1}$

$\lambda = \frac{2\pi}{k} = \frac{2\pi}{(\frac{\pi}{2})} = \frac{4\pi}{\pi} = 4\ cm.$

$T = \frac{2\pi}{\omega} = \frac{2\pi}{2\pi} = 1s$

$f = \frac{1}{T} = 1s^{-1} = 1Hz$

$v = f\lambda$

↑ unit of cms^{-1}

$v = (1Hz)(4cm)$

$\boxed{v = 4\ cms^{-1}}$

Ok? ← kalau ok, chat !!!

Sample Problem 1

1. A progressive wave is represented by the equation

$$y = 5sin(2\pi t + \frac{\pi}{2}x)$$

Where y and x are in centimetres and t is in seconds. Determine the amplitude, angular frequency, wavelength, period, frequency, wave speed and direction of motion.

Can we use $\omega = 2\pi f$ to calculate frequency?

$$\left.\begin{aligned} f &= \frac{\omega}{2\pi} \\ f &= T^{-1} \end{aligned}\right\} \quad T = \frac{2\pi}{\omega}$$

this is true

therefore $\Longrightarrow$ $f = \frac{\omega}{2\pi}$ will yield same answer as $T = \frac{2\pi}{\omega}$ ✓

okay?

Sample Problem 2

2. with the speed of sound $v_{sound} = 333ms^{-1}$, find the minimum length of the pipe that has a fundamental frequency of $300Hz$ if the pipe is

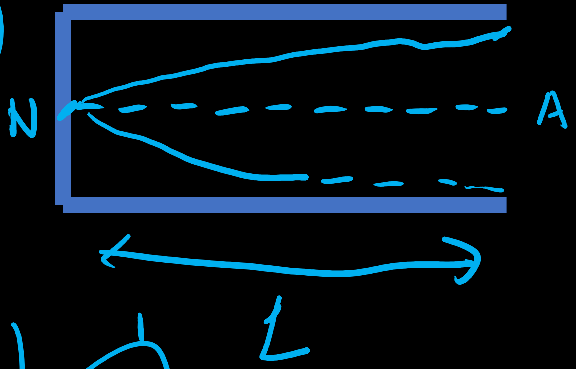
   a) closed at one end

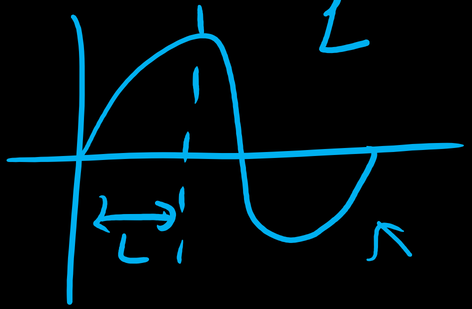
   b) opened at both ends.

} 2 case studies

$(V = 333ms^{-1})$

a)





$L = \frac{1}{4}\lambda$

$\lambda = 4L$

$V = f\lambda$

$V = f(4L)$

$\frac{V}{4f} = L$

$L = \frac{V}{4f} = \frac{333}{4(300)} \approx 0.2775\ m$

m/s

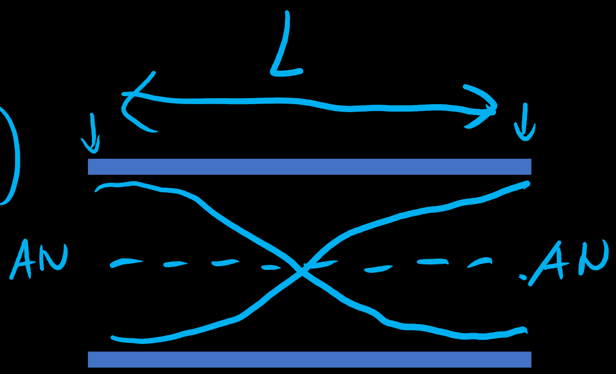
Sample Problem 2

2. with the speed of sound $v_{sound} = 333ms^{-1}$, find the minimum length of the pipe that has a fundamental frequency of $300Hz$ if the pipe is

   a) closed at one end

   b) opened at both ends.

b)



$L = \frac{1}{2}\lambda$

$\lambda = 2L.$

$V = f\lambda$

$V = 2Lf$

$L = \frac{V}{2f} = \frac{333}{2(300)} \simeq 0.555\, m.$

Homework

10.2 Superposition of Waves

1. The following two waves are superposed;

$$y_1(x,t) = 6\ sin(2t - 3x)$$

$$y_2(x,t) = \cancel{6}\ \underset{7}{}\ sin(2t + 3x)$$

What type of wave is formed? Derive the equation of the resulting wave.

Homework !!!

Thank you!

23rd September 2021

Past session HW

10.2 Superposition of Waves

1. The following two waves are superposed;

$$y_1(x, t) = 6\ sin(2t - 3x)$$

$$y_2(x, t) = \cancel{6}\ sin(2t + 3x)$$

7

What type of wave is formed? Derive the equation of the resulting wave.

Past session HW

Homework

0.2 Superposition of Waves

1. The following two waves are superposed;

$$y_1(x,t) = 6\sin(2t - 3x)$$
$$y_2(x,t) = 7\sin(2t + 3x) \qquad w = 2 \qquad k = 3$$

What type of wave is formed? Derive the equation of the resulting wave.

Stationary wave and progressive wave

Equation for stationary waves

$$y = 2A \sin wt \cos kx$$

Wave equation : Principle of superposition

$$y = y_1 + y_2$$

$$y = 6\sin(2t-3x) + 7\sin(2t+3x)$$
$$= 6\sin(2t-3x) + 6\sin(2t+3x) + \sin(2t+3x)$$
$$= 6\left[(\sin 2t \cos 3x - \cos 2t \sin 3x) + (\sin 2t \cos 3x + \cos 2t \sin 3x)\right] + \sin(2t+3x)$$
$$= 6(2\sin 2t \cos 3x) + \sin(2t+3x)$$
$$= \underset{\substack{\uparrow \\ \text{Standing wave}}}{12\sin 2t \cos 3x} + \underset{\substack{\uparrow \\ \text{progressive wave}}}{\sin(2t+3x)}$$

10.2 Superposition of Waves

1. The following two waves are superposed;

$$y_1(x,t) = 6\ sin(2t - 3x)$$
$$y_2(x,t) = \cancel{6}\,7\ sin(2t + 3x)$$

What type of wave is formed? Derive the equation of the resulting wave.

Amin.

Past session HW

Ain. punyal

10.2 Superposition of Waves

1. The following two waves are superposed;

$$y_1(x,t) = 6\ sin(2t - 3x)$$

$$y_2(x,t) = \cancel{6}\ 7\ sin(2t + 3x)$$

What type of wave is formed? Derive the equation of the resulting wave.

1) The following two waves are superposed;

$$y_1(x,t) = \overset{A}{6}\ \sin(\overset{\omega}{2}t - \overset{k}{3}x)$$

$$y_2(x,t) = 7\ \sin(2t+3x)$$

What type of wave is formed? Derive the equation of the resulting wave.

Standing wave. $y = 2A \cos kx \sin \omega t$

$\sin\alpha + \sin\beta = 2\sin\left(\frac{\alpha+\beta}{2}\right)\cos\left(\frac{\alpha-\beta}{2}\right)$ $\cancel{y = y_1 + y_2 = 2A \cos kx \sin \omega t}$

$y = 6 \sin(2t-3x) + 7\sin(2t+3x)$

$= [6\sin(2t-3x) + 6\sin(2t+3x)] + \sin(2t+3x)$

$= 2(6)\sin\left[\frac{(2t-3x)+(2t+3x)}{2}\right]\cos\left[\frac{(2t-3x)-(2t+3x)}{2}\right] + \sin(2t+3x)$

$= 12\sin\left(\frac{2t+2t-3x+3x}{2}\right)\cos\left(\frac{2t-2t-3x-3x}{2}\right) + \sin(2t+3x)$

$= 12\sin\left(\frac{4t}{2}\right)\cos\left(-\frac{6x}{2}\right) + \sin(2t+3x)$

$= 12\sin(2t)\cos(-3x) + \sin(2t+3x)$

$= 12\ \overset{\cos -3x}{\cancel{\sin -3x}}\ \sin 2t + \sin(2t+3x)$

$$\boxed{A \sin(\omega t \pm kx)}$$

1 possible solution

Sample Problem 1 - Doppler effect

If a music box produces a tone of 500Hz as a boy is running towards the music box at $2\frac{m}{s}$, what is the frequency the boy hears?

$[v_{sound\ in\ air} = 343\frac{m}{s}]$

$$f' = \left(\frac{V \pm V_o}{V \mp \cancel{V_s}\ 0}\right) f_{real}$$

apparent

$f' > f_{real}$: A $\Rightarrow$ ① > ②

$f' < \cancel{f_{real}}$: B

$\frac{①}{②} \Rightarrow > 1$.

$\frac{①}{②} > 1$

$$f' = \left(\frac{V \pm V_o}{V}\right) f_{real}$$

$$f' = \left(\frac{V + V_o}{V}\right) f_{real}$$

$$f' = \left(1 + \frac{2}{343}\right)(500\text{Hz})$$

$$f' = 502.92\text{Hz}$$

Sample Problem 2

Suppose a car moves at $15\frac{\mathrm{m}}{\mathrm{s}}$ and produces a $500\mathrm{Hz}$ honk. A runner running at $3\frac{\mathrm{m}}{\mathrm{s}}$ approaches the car. About what frequency does the runner hear?

15 ms⁻¹

car

→ +

500Hz

$f' = \left(\frac{V \pm V_o}{V \mp V_s}\right) f_{real}$

$\boxed{f' > f_{real}}$

$\boxed{① >> ②}$

3 ms⁻¹

← −   → +

$\boxed{V_{air} = 343\,ms^{-1}}$

exam paper

given

$f' = \left(\frac{V + V_o}{V - V_s}\right) f_{real}$

$f' = \left(\frac{343 + 3}{343 - 15}\right)(500)$

$f' \approx 527.439\,Hz$

Homework

(b) A man stands by the roadside when an ambulance passes by him with constant velocity 18 m s-1. The ambulance emits siren with frequency $256Hz$. The speed of sound is $340ms^{-1}$.

i. Calculate the apparent frequency of the siren heard by the man before the ambulance passes by him.
ii. Sketch a graph of the apparent frequency against distance travelled.
iii. Sketch a graph of siren intensity against distance.

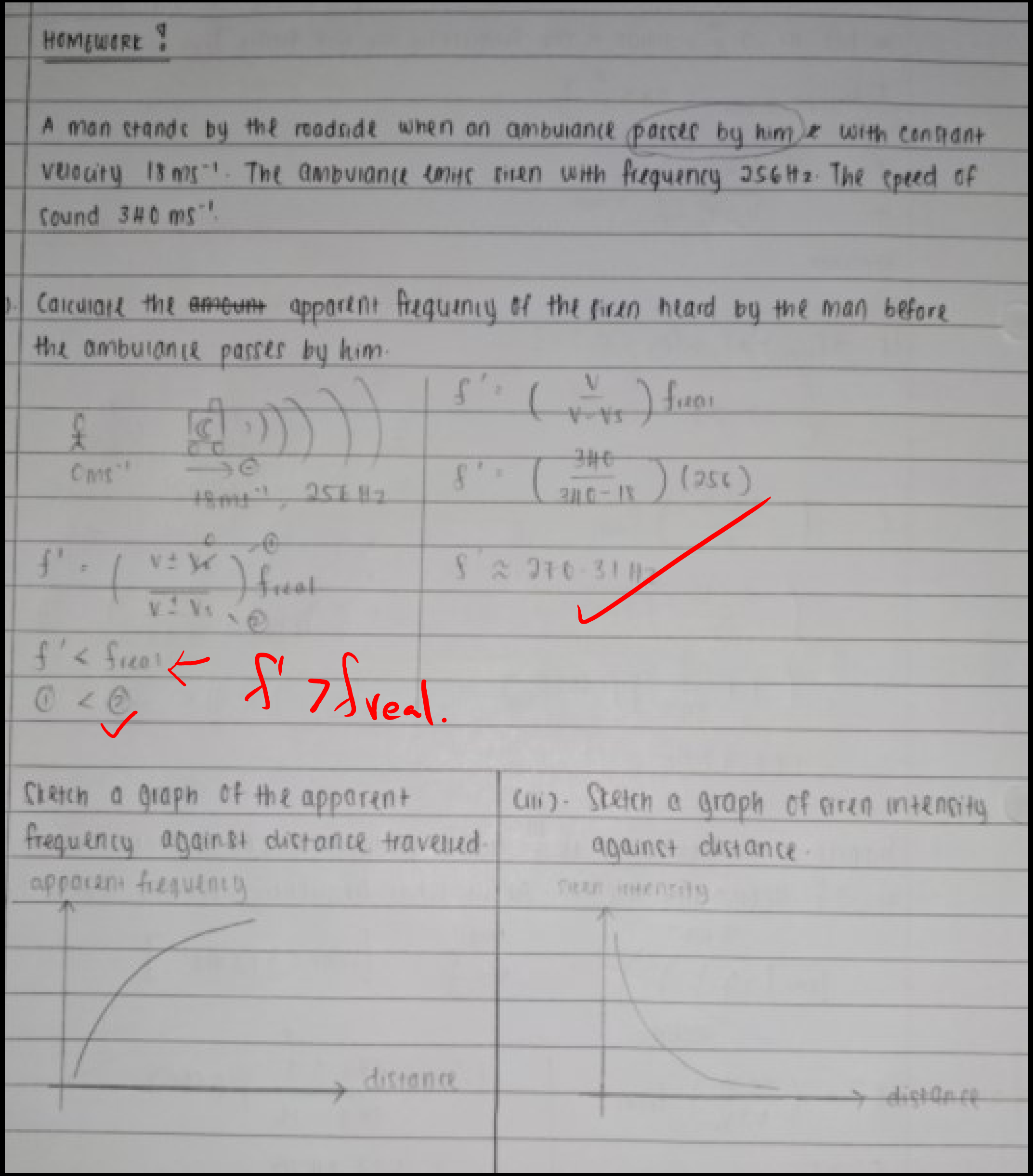
Past year!

Thank you!

24 September 2021

Homework

Wellena



HOMEWORK :

A man stands by the roadside when an ambulance passes by him with constant velocity $18\ ms^{-1}$. The ambulance emits siren with frequency 256 Hz. The speed of sound $340\ ms^{-1}$.

i) Calculate the ~~amount~~ apparent frequency of the siren heard by the man before the ambulance passes by him.

$0\ ms^{-1}$ $18\ ms^{-1}$, 256 Hz

$f' = \left(\frac{v \pm v_o}{v \mp v_s}\right) f_{real}$

$f' < f_{real}$ ← $f' > f_{real}$.

$O < S$

$f' = \left(\frac{v}{v - v_s}\right) f_{real}$

$f' = \left(\frac{340}{340 - 18}\right)(256)$

$f' \approx 270.31$ Hz

Sketch a graph of the apparent frequency against distance travelled.

apparent frequency

distance

(iii) Sketch a graph of siren intensity against distance.

siren intensity

distance

(b) A man stands by the roadside when an ambulance passes by him with constant velocity 18 m s-1. The ambulance emits siren with frequency $256Hz$. The speed of sound is $340ms^{-1}$.

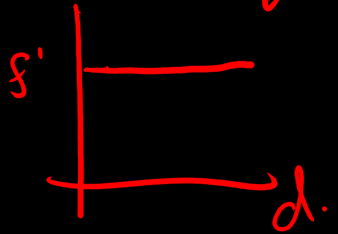
i. Calculate the apparent frequency of the siren heard by the man (before the ambulance passes) by him.

ii. Sketch a graph of the (apparent frequency) against distance travelled.

iii. Sketch a graph of siren intensity against distance.

$f'(v)$

f' vs $d \Rightarrow f'(V_{air}, V_{obs}, V_{source})$



I vs d.

Homework

i. $V_o = 0\ ms^{-1}$

$V_s = 18\ ms^{-1}$

$V = 340\ ms^{-1}$

$f_{real} = 256\ Hz$

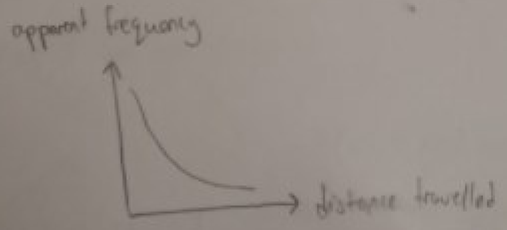
$f_{apparent} > f_{real}$ (before ambulance pass)

$$f_{apparent} = \left(\frac{V \pm V_o}{V \pm V_s}\right)(f_{real})$$

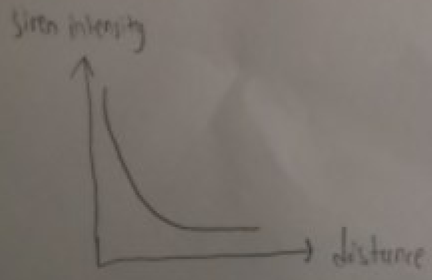
$$= \left(\frac{340 + 0}{340 - 18}\right)(256)$$

$$= 270.31\ Hz$$

ii.



iii.



(b) A man stands by the roadside when an ambulance passes by him with constant velocity 18 m s-1. The ambulance emits siren with frequency $256Hz$. The speed of sound is $340ms^{-1}$.

i. Calculate the apparent frequency of the siren heard by the man before the ambulance passes by him.

ii. Sketch a graph of the apparent frequency against distance travelled.

iii. Sketch a graph of siren intensity against distance.

Homework

(b) A man stands by the roadside when an ambulance passes by him with constant velocity 18 m s-1. The ambulance emits siren with frequency $256 Hz$. The speed of sound is $340 ms^{-1}$.

i. Calculate the apparent frequency of the siren heard by the man before the ambulance passes by him.

ii. Sketch a graph of the apparent frequency against distance travelled.

iii. Sketch a graph of siren intensity against distance.

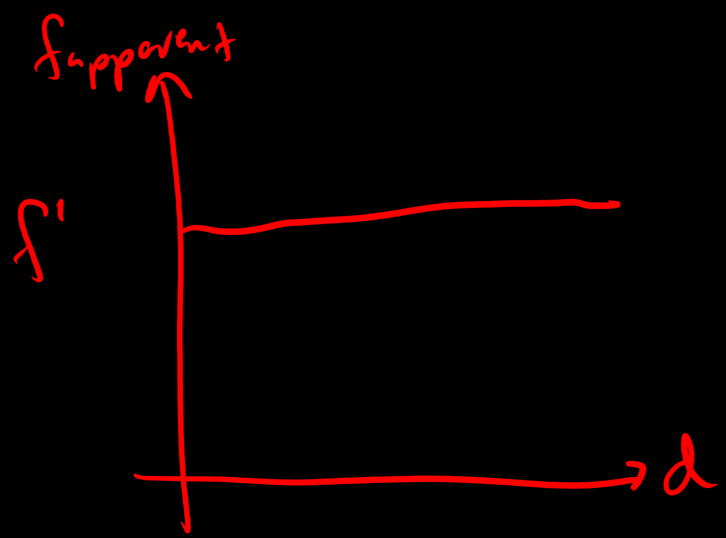
ada soalan?

ii) f' vs d

f' is independent of distance travelled, d., according to

$$f' = \left(\frac{V \pm V_0}{V \mp V_s}\right) f_{real}.$$

therefore,



okay? like the rice =)

Homework

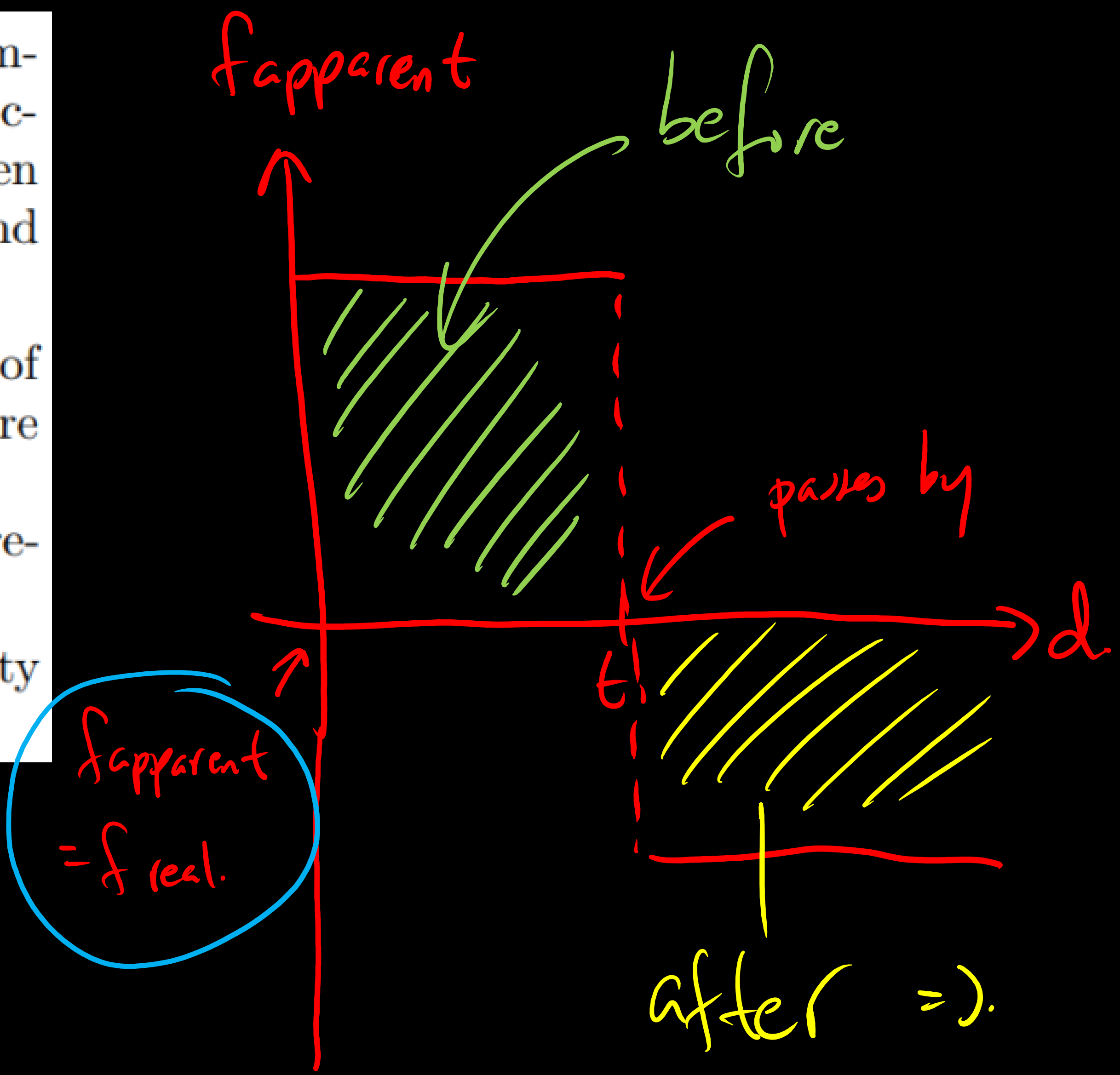
(b) A man stands by the roadside when an ambulance passes by him with constant velocity 18 m s-1. The ambulance emits siren with frequency $256Hz$. The speed of sound is $340ms^{-1}$.

i. Calculate the apparent frequency of the siren heard by the man before the ambulance passes by him.

ii. Sketch a graph of the apparent frequency against distance travelled.

iii. Sketch a graph of siren intensity against distance.

Ambulance passes by the man at time t



Homework

(b) A man stands by the roadside when an ambulance passes by him with constant velocity 18 m s-1. The ambulance emits siren with frequency 256Hz. The speed of sound is 340ms^{-1}.

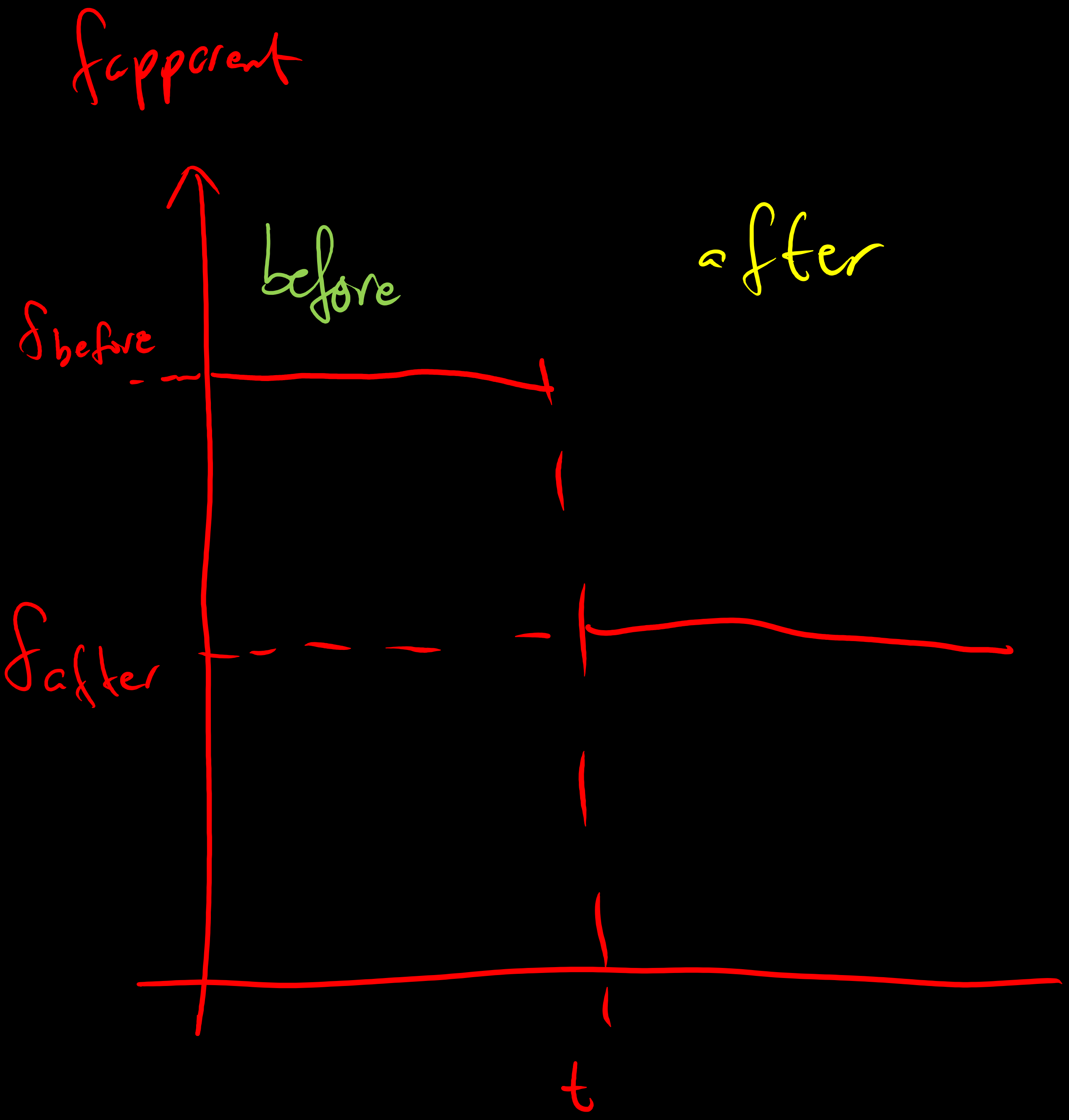
i. Calculate the apparent frequency of the siren heard by the man before the ambulance passes by him.

ii. Sketch a graph of the apparent frequency against distance travelled.

iii. Sketch a graph of siren intensity against distance.

$f_{before} > f_{real}$

$f_{after} < f_{real}$



Homework

(b) A man stands by the roadside when an ambulance passes by him with constant velocity 18 m s-1. The ambulance emits siren with frequency 256Hz. The speed of sound is 340ms^{-1}.

i. Calculate the apparent frequency of the siren heard by the man before the ambulance passes by him.

ii. Sketch a graph of the apparent frequency against distance travelled.

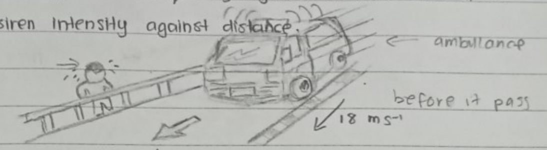
iii. Sketch a graph of siren intensity against distance.

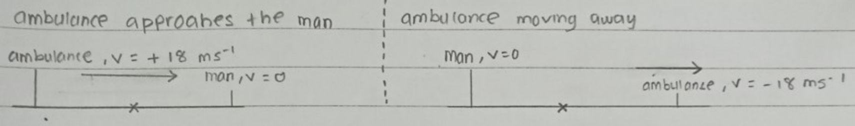
A man stands by the roadside when an ambulance passes by him with constant velocity 18 m s^{-1}. The ambulance emits siren with frequency 256 Hz. The speed of sound is 340 ms^{-1}.

i. Calculate the apparent frequency of the siren heard by the man before the ambulance passes by him.

ii. Sketch a graph of the apparent frequency against distance travelled.

iii. Sketch a graph of siren intensity against distance.





Applying Doppler's equation : $f_o = f_s \left[\frac{v \pm v_o}{v \mp v_s}\right]$

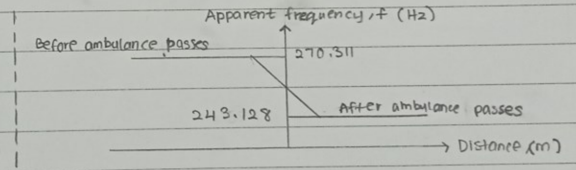
(i) $f_o = 256 \left[\frac{340 + 0}{340 - 18}\right]$

$= 270.311$ Hz (ambulance approahes the man)

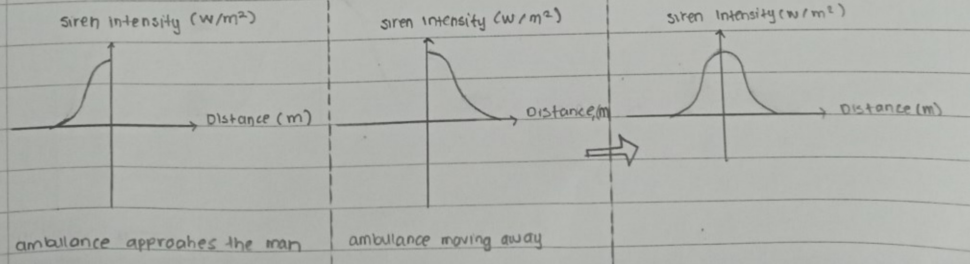
(ii) $f_o = 256 \left[\frac{340 - 0}{340 + 18}\right]$

$f_o = 243.128$ Hz

(ambulance moving away)



(iii) $I = \frac{P}{4\pi R^2}$ Distance increases, Intensity decreaces



Homework

(b) A man stands by the roadside when an ambulance passes by him with constant velocity 18 m s-1. The ambulance emits siren with frequency $256 Hz$. The speed of sound is $340 ms^{-1}$.

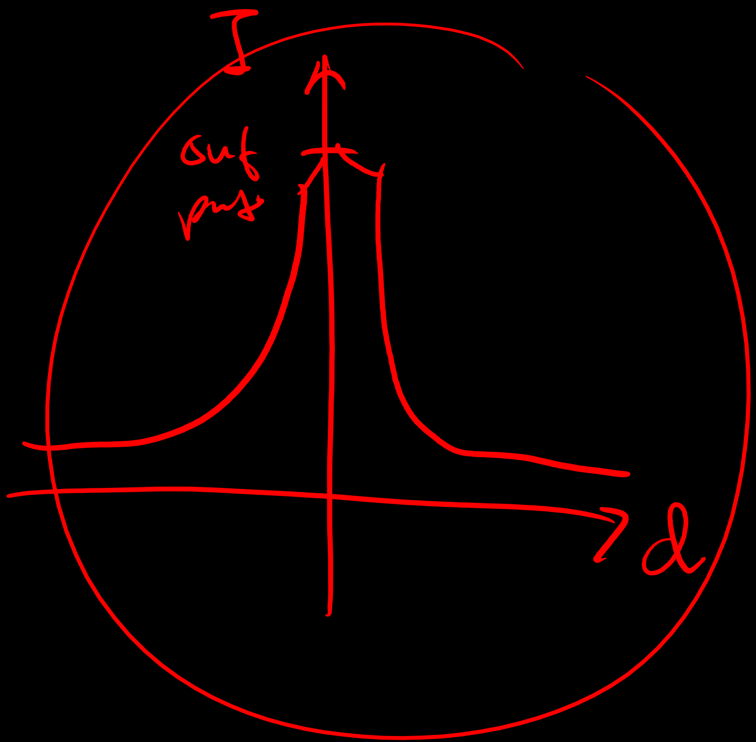
i. Calculate the apparent frequency of the siren heard by the man before the ambulance passes by him.

ii. Sketch a graph of the apparent frequency against distance travelled.

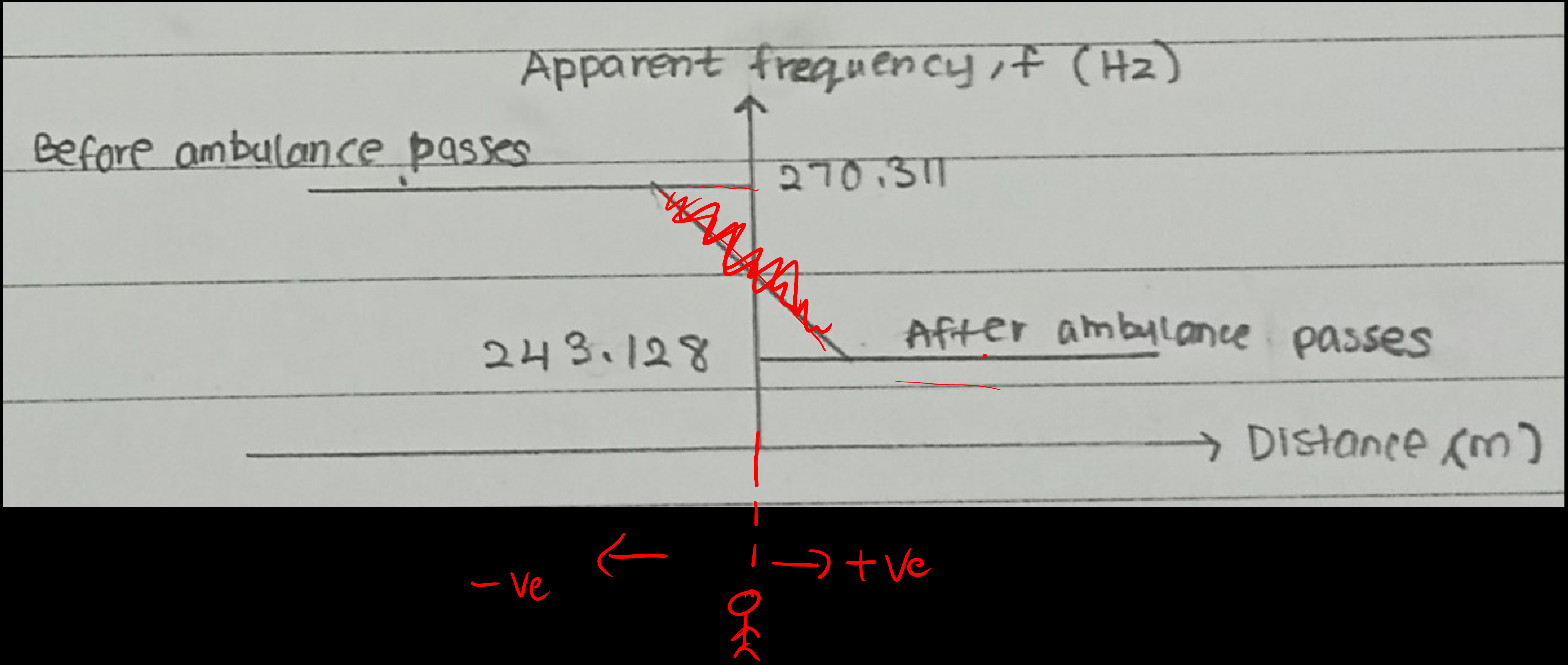
iii. Sketch a graph of siren intensity against distance.

ii) $\boxed{I \propto \frac{1}{R^2}}$

$\boxed{R = d}$



Homework



Apparent frequency, f (Hz)
Before ambulance passes
270.311
243.128
After ambulance passes
Distance (m)
-ve
+ve

Sample Problem 1

A mechanical wave propagates at $550ms^{-1}$ along a string stretched to a tension of $800N$. The string oscillates at fundamental frequencyn $440Hz$. Calculate the

i. mass per unit length of the string

ii. length of the string

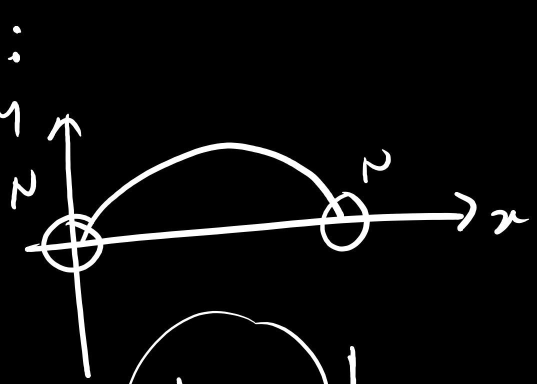
iii. frequency of the second overtone **and** sketch the waveform of the overtone

$V = 550ms^{-1}$

$T = 800N$

$f_0 = 440Hz$

f_0:



$\frac{1}{2}\lambda = L$

μ?

$V^2 = \frac{T}{\mu}$

$\mu = \frac{T}{V^2}$

$\mu = \frac{800}{550^2}$

$\boxed{\mu} = 0.00264\ kgm^{-1}$

$V = f\lambda$

$V = f(2L)$

$L = \frac{V}{2f} = \frac{550}{2(440)} \simeq 0.625m$

Sample Problem 1

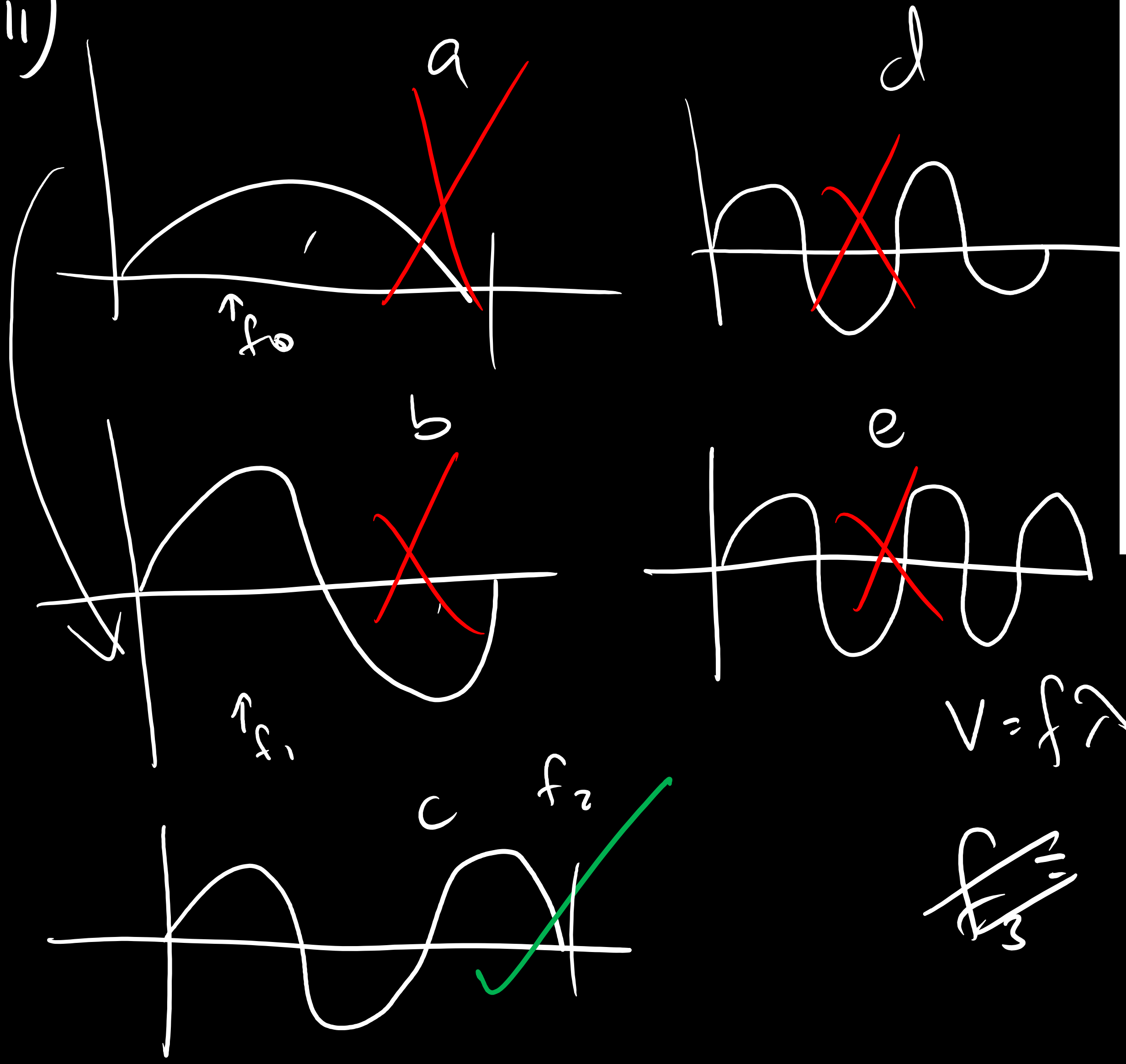
A mechanical wave propagates at $550ms^{-1}$ along a string stretched to a tension of $800N$. The string oscillates at fundamental frequencyn $440Hz$. Calculate the

i. mass per unit length of the string

ii. length of the string

iii. frequency of the second overtone **and** sketch the waveform of the overtone

iii)



$v = f\lambda \nearrow \lambda = 2L = \frac{v}{f}$

$f_2 = 3(440)$

$\approx 1320\ Hz$

$\cancel{f_3 =}$

$\frac{3}{2}\lambda = L \Rightarrow \lambda = \boxed{\frac{2}{3}L = \frac{v}{f}}$?

$f_2 = \frac{3v}{2L} = 3f_0$

Sample Problem 2

a violin string has mass per unit length $0.01kgm^{-1}$ and experiences a tension of $0.36N$. Calculate the wavelength if it vibrates at a frequency of $8Hz$.

$\mu = 0.01\ kg/m$

$T = 0.36N$

$f = 8Hz$

$$v = \sqrt{\frac{T}{\mu}} = f\lambda$$

Physical consideration

characterization of parameters

$$\lambda = \frac{1}{f}\sqrt{\frac{T}{\mu}} = \frac{1}{8}\sqrt{\frac{0.36}{0.01}}$$

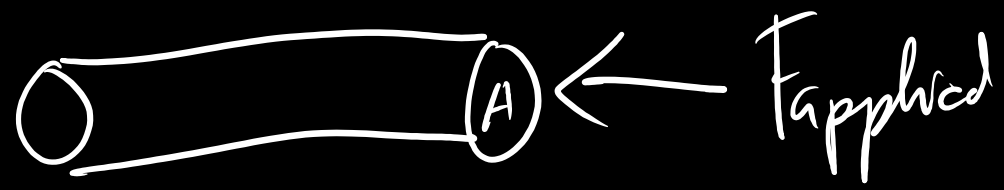
$$\lambda = 0.75\ m.$$

Thank you!

Solid Deformation

28 September 2021

Stress vs Strain



Apakah itu 'stress'?

$$\sigma = \frac{F}{A}$$

F ← force

A ← area

Stress can deform the body.

deform: Shape change ← quantify? ⇒ Strain,

$$\varepsilon = \frac{\Delta L}{L}.$$

1D

Young's Modulus

$$Y = \frac{\delta}{\varepsilon}$$

relationship
antara
stress
&
strain

$$\delta = \boxed{Y}\,\varepsilon$$

~~strain~~ stress — constant — strain

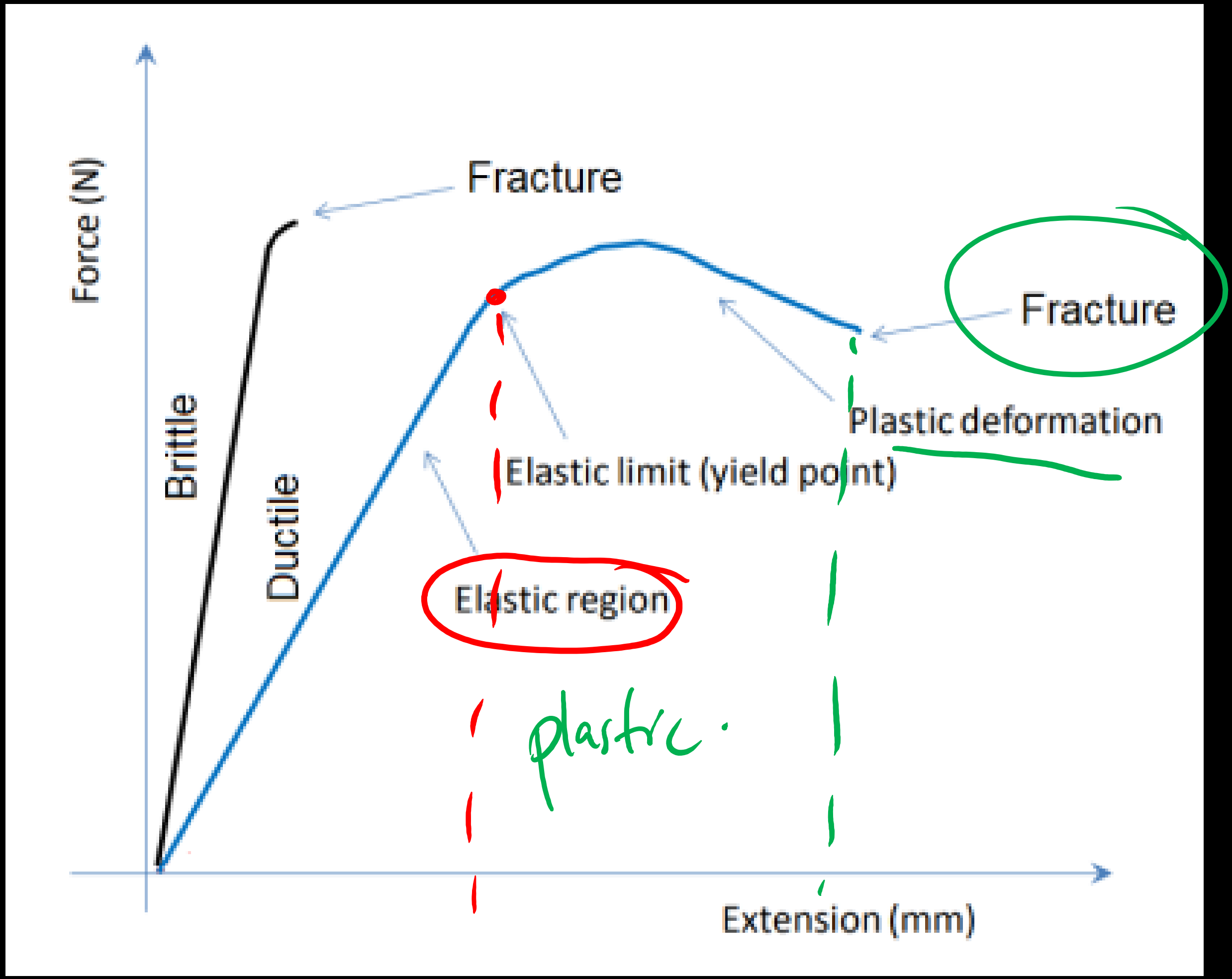
$$\delta \propto \varepsilon$$

Elastic vs Plastic Deformation

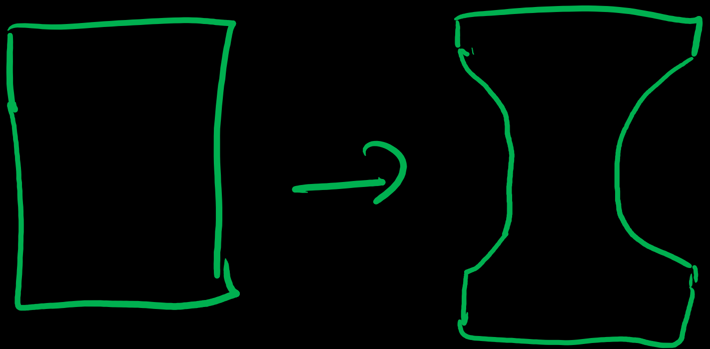
reversible deformation

irreversible deformation

Force Elongation Graph



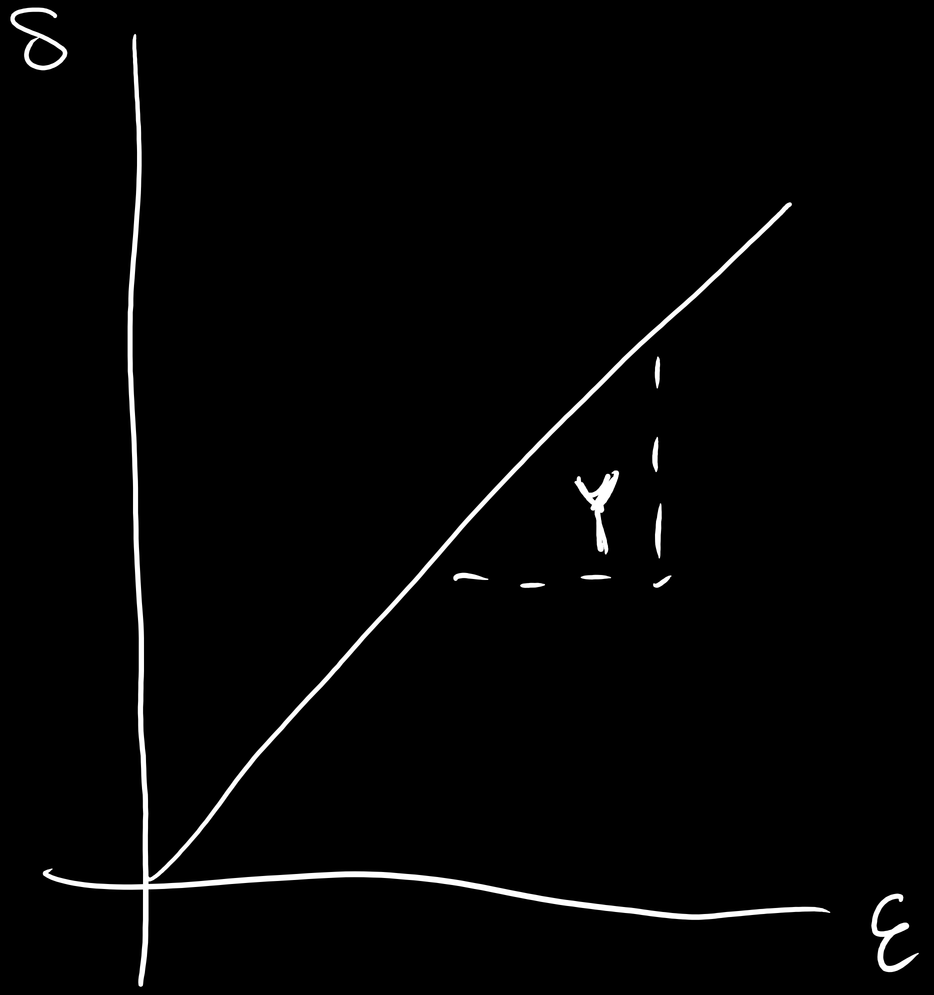
Brittle : force ↑, extension ↑, reaches elastic limit, fracture.



: necking

Ductile : after elastic limit
→ plastic deformation
→ fracture

Stress-Strain Graph

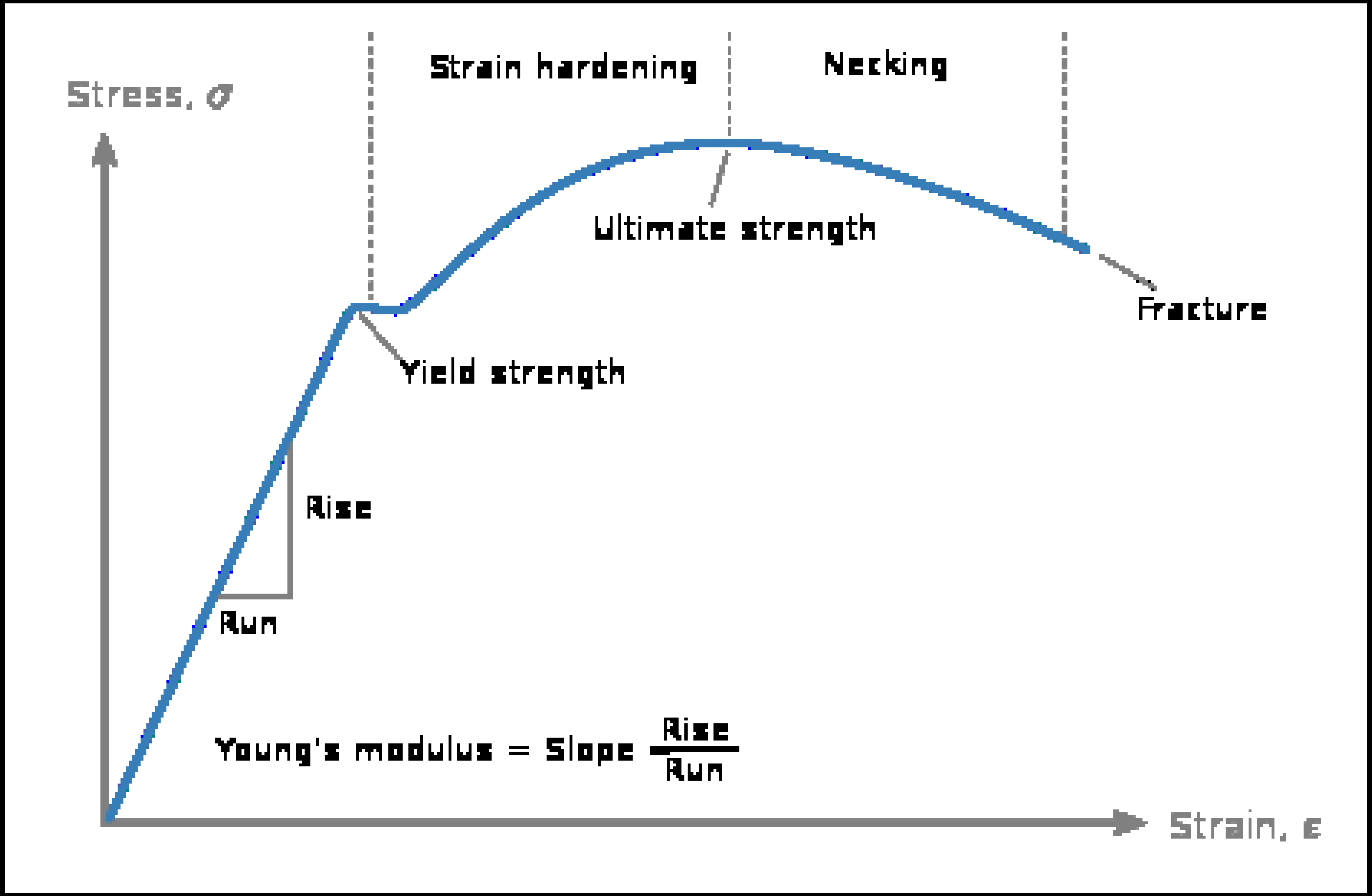


$\delta = Y\varepsilon$

$y = mx$

$m = Y$

Stress-Strain Graph



Thank you!

Chapter 11

Solid deformation

30 September 2021

Sample Problem 1

5. **(PSPS 14/15)**

(a) Explain plastic deformation of an elastic material.

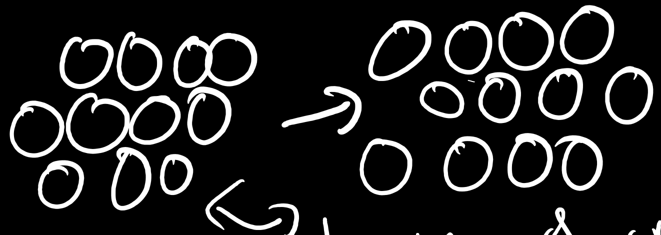
(b) A wire of diameter $0.5mm$ has Young's modulus of $2 \times 10^{11} Nm^-1$. Calculate the strain if it is extended by $150N$ load.

a) plastic deformation

def. : cannot go back to original shape

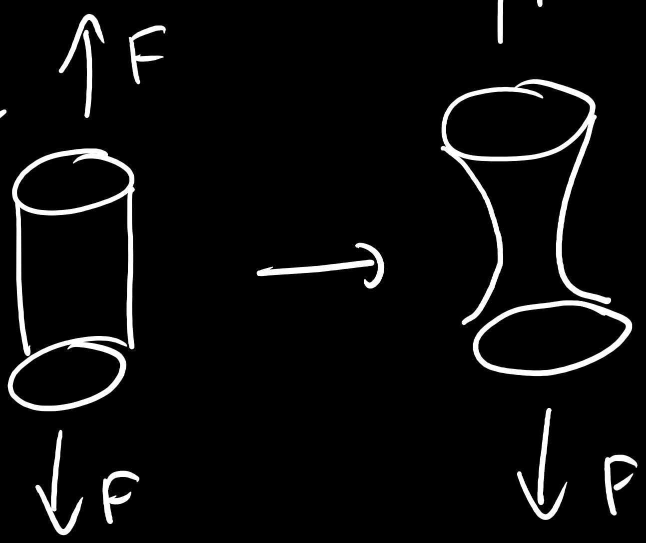
2 ~~plas~~ phase

① strain hardening

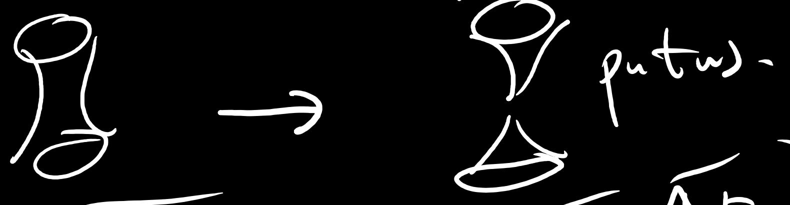


dislocation of crystal plane

② necking (after UTS)



At fracture point



Sample Problem 1

5. **(PSPS 14/15)**
   (a) Explain plastic deformation of an elastic material.
   (b) A wire of diameter $0.5mm$ has Young's modulus of $2 \times 10^{11} Nm^{-}1$. Calculate the strain if it is extended by $150N$ load.

$d = 0.5\,mm \rightarrow A = \pi r^2 = \pi\left(\frac{d}{2}\right)^2 = \pi(0.25\,mm)^2 = 6.25\pi(10^{-8})\,m^2$

10^{-3}

$Y = 2(10^{11})\,Nm^{-1}$

strain if $W = 150N$

$Y = \frac{S}{\varepsilon}$

$\varepsilon = \frac{S}{Y} = \left(\frac{F}{A}\right)\left(\frac{1}{Y}\right)$

$\varepsilon = \left(\frac{150}{6.25\pi(10^{-8})}\right)\left(2(10^{11})\right)^{-1}$

$\varepsilon \simeq 3.82 \times 10^{-3}$

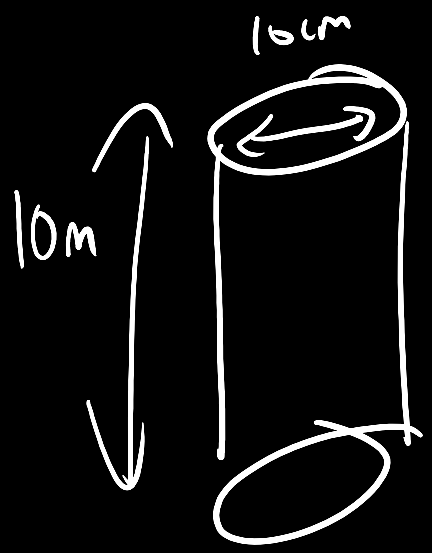
unitless

Engineer convention

m/m.

Sample Problem 2

6. **(PSPS 16/17)**
A solid cylinder $10m$ high and $10cm$ in diameter is compresses by a 1×10^5 kg load. Calculate the strain energy stored in the cylinder. The Young's modulus of cylinder is $1.9 \times 10^{11} Pa$.



$\downarrow F = W = mg$

$m = 10^5$

Hooke's Law: $F = -kx$; $U = \frac{1}{2} k x^2$ ← compression

$$Y = \frac{F}{A}\left(\frac{L}{\Delta L}\right) \rightarrow Y = \frac{F}{A}\left(\frac{L}{x}\right) \rightarrow x^{-1} = \frac{YA}{FL}$$

$x = \Delta L.$

$$U = \frac{1}{2} k (x^2) = \frac{1}{2} F x$$

$$U = \frac{1}{2} F \left(\frac{FL}{YA}\right) = \frac{1}{2} \frac{F^2 L}{YA}$$

$Y = 1.9 \times 10^{11}$ Pa.

$\sigma = F/A$; $\varepsilon = \frac{\Delta l}{l}$ ← change in shape

$$\frac{1}{\varepsilon} = \frac{l}{\Delta l}$$

Sample Problem 2

6. **(PSPS 16/17)**
A solid cylinder $10m$ high and $10cm$ in diameter is compresses by a $1 \times 10^5\ kg$ load. Calculate the strain energy stored in the cylinder. The Young's modulus of cylinder is $1.9 \times 10^{11} Pa$.

$$U = \frac{1}{2}\frac{F^2 L}{YA}$$

$$A = \pi r^2 = \pi (5cm)^2$$

$$Y = 1.9(10^{11})$$

$$F^2 = [(10^5)(9.81)]^2$$

$$L = 10m$$

$$U = \frac{1}{2}\left[\frac{(10^5 \times 9.81)^2 (10m)}{1.9(10^{11})[\pi][5(10^{-2})]^2}\right]$$

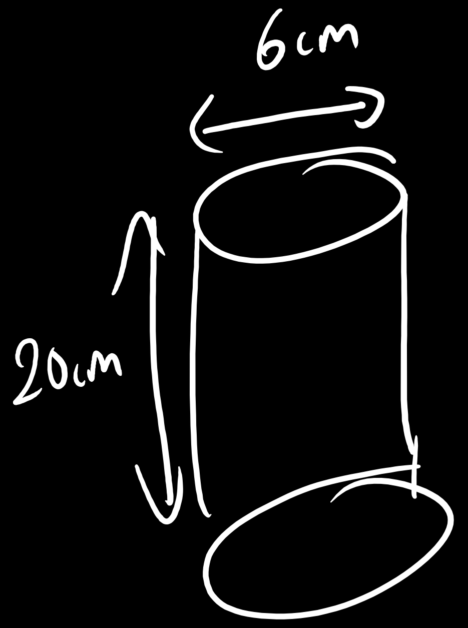
$$U = 3224.5\ J$$

#

Sample Problem 3

7. **(PSPS 17/18)**

A $20cm$ cylindrical brass rod with diameter $6cm$ is held vertically on its one circular flat end. A load of $5kg$ is placed on its upper end. Given the Young's modulus of brass is $9.1 \times 10^{10} Nm^{-2}$, calculate the strain energy of the rod.



$Y = 9.1(10^{10})\,Nm^{-2}$

$\downarrow\ 5kg\,(9.81) = W$

$$U = \frac{1}{2}\left(\frac{F^2 L}{YA}\right)$$

$$U = \frac{1}{2}\left(\frac{[5(9.81)]^2[20\times10^{-2}]}{9.1(10^{10})(\pi)(3\times10^{-2})^2}\right)$$

$$U = 9.35\times10^{-7}\ J$$

#.

Tomorrow:

discuss 1 more question & submit

tutorial + PY.

Thank you!

1ST Oct 2021

Sample Problem 1

The radius of a copper bar is 4 mm. What force is required to stretch the rod by 20% of its length assuming that the elastic limit is not exceeded? $Y = 12 \times 10^{10}\ N/m^2$.

$r = 4mm$

$A = \pi r^2 = 16(10^{-6})\pi\ m^2$

$[\Delta L = 20\%(L) \Rightarrow \frac{\Delta L}{L} = \varepsilon = \boxed{0.2}]$

$Y = 12\times10^{10}\ Nm^2$

$Y = \frac{FL}{A\Delta L}$

$Y = F\left(\frac{1}{A}\right)\left(\frac{L}{\Delta L}\right)$

$Y = \frac{F}{A}\left(\frac{1}{\varepsilon}\right)$

$\boxed{F = A\varepsilon Y}$

$F = 16(10^{-6})(0.2)(12\times10^{10})\pi$

$F = (16\times12)(10^{10-6})(0.2)\pi$

$F = 384000\pi\ N$

$F \approx 1206371.5N$

$\frac{F}{A} = F\left(\frac{1}{A}\right)$

$\Delta L = 20\%(L)$

$\Downarrow$

$\frac{\Delta L}{L} = 20\% = 0.2$

Sample Problem 2

Elastic limit is exceeded when the strain in a wire ($Y = 14 \times 10^{11}$ N/m²) exceeds 1/2000. If the area of the cross-section of the wire is 0.02 cm², find the maximum load that can be used for stretching the wire without causing a permanent set.

$\varepsilon = \frac{1}{2000} \simeq 5(10^{-4})$

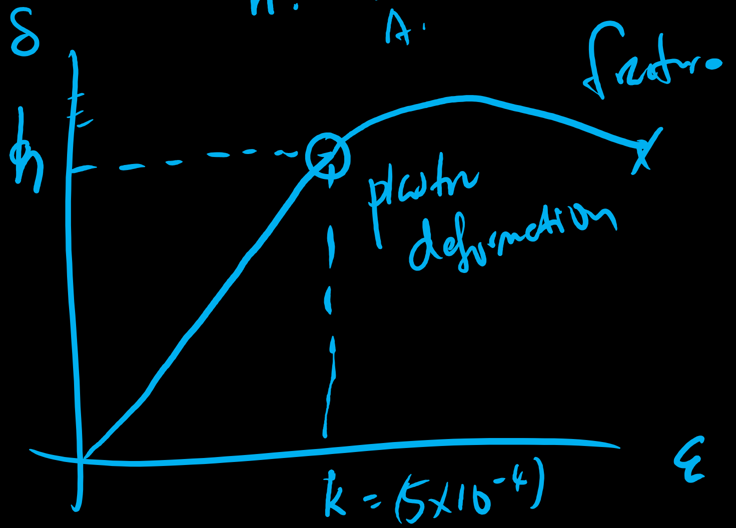
$A = [0.02\ c]m^2 = 0.02(10^{-4})$ m^2

$\simeq 0.02(10^{-4})$ m^2

F_{max} ?

$Y = 14 \times 10^{11}\ Nm^2$

$h? = \frac{F_{max}}{A}$



$Y = \frac{\delta}{\varepsilon} = \frac{F}{A}\left(\frac{1}{5\times10^{-4}}\right)$

max strain before elastic limit

$F_{max} = YA(5\times10^{-4})$

$= (14)(0.02)(10^{11-4})[5][10^{-4}]$

$F_{max} = 1400N$

Thank you!

4 October 2021

PSPM 0506

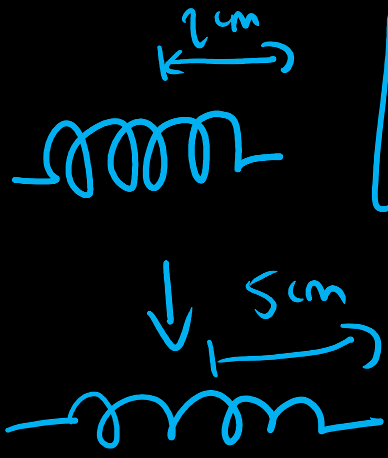
A 10.0 J of work is needed to stretch an elastic spring by 2.0 cm. Calculate the work required to further extend the spring to 5.0 cm.

x_i	x_f	
0 $\longrightarrow$	5cm	X
$\boxed{2cm}$ $\longrightarrow$	5cm	✓

Work-energy : Work = change in energy

$10J = W = E_{ep} = \boxed{\frac{1}{2}}kx^2$; $k = \frac{2W}{x^2}$

$k = \frac{2(10)}{(0.02)^2} \approx 5(10^4)\,Nm^{-1}$



$W = \frac{1}{2}kx^2$

$W = \frac{1}{2}(5)(10^4)(0.05)^2$

$\approx 62.5J$

$W(x = 0.05m) \approx 62.5J$

$W(x = 0.05m) - W(x = 0.02m) = \Delta W$

$62.5 - 10 = \Delta W$

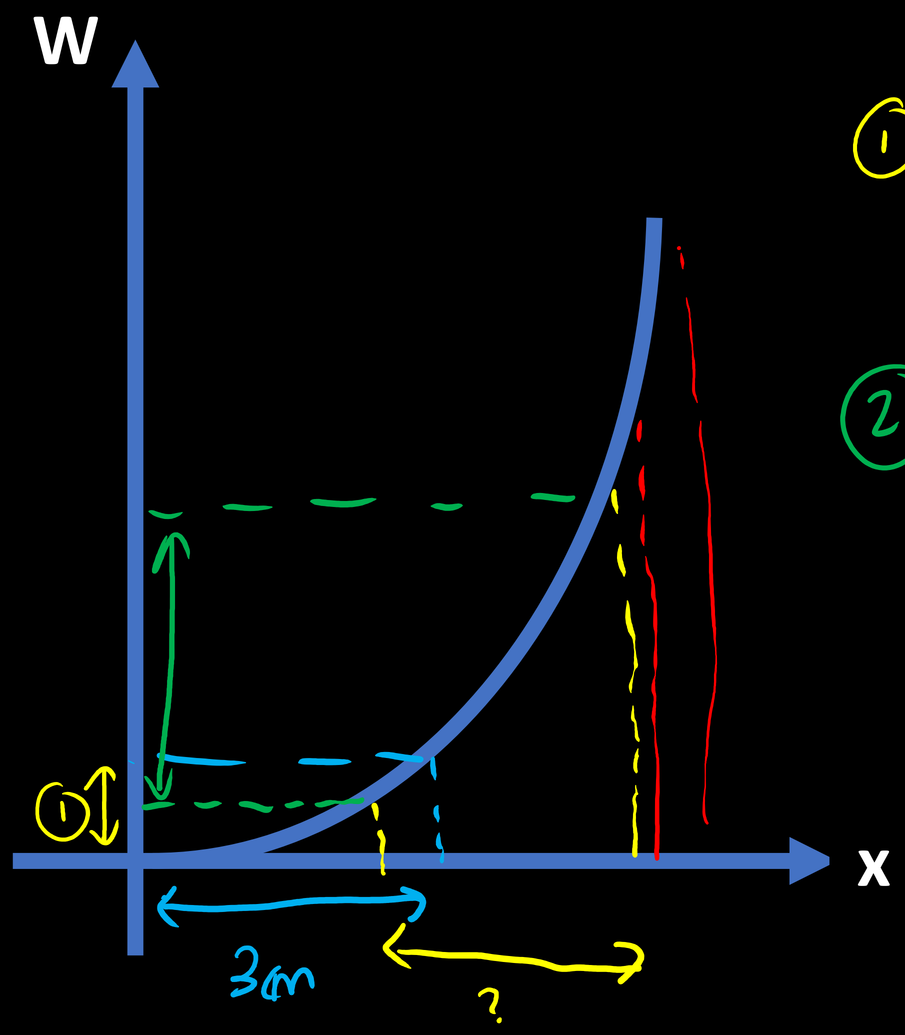
$\Delta W = 52.5J$

$W = \frac{1}{2}kx^2$ ← 3cm

PSPM 0506

A 10.0 J of work is needed to stretch an elastic spring by 2.0 cm. Calculate the work required to further extend the spring to 5.0 cm.

$W = \frac{1}{2}kx^2$



① $W(0 \rightarrow 3\text{cm})$

$\neq$

② $W(2 \rightarrow 5\text{cm})$

PSPM 0506

A 2 m taut string is plucked at its centre producing vibrations with fundamental frequency of 40 Hz.

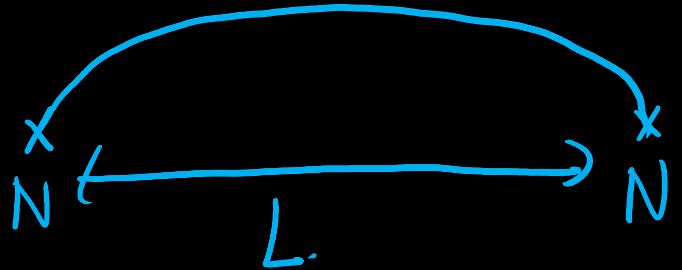
a. Calculate the velocity of the transverse wave propagating in the string.

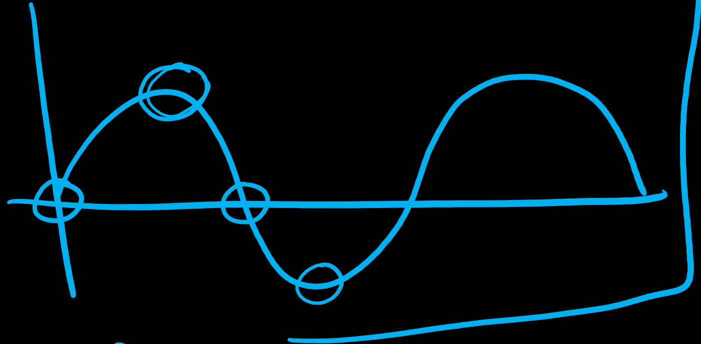
b. At what position should the string be plucked to produce vibrations at frequency 160 Hz?

funda

2nd

4th





$V = f\lambda$

$V = 2fL$

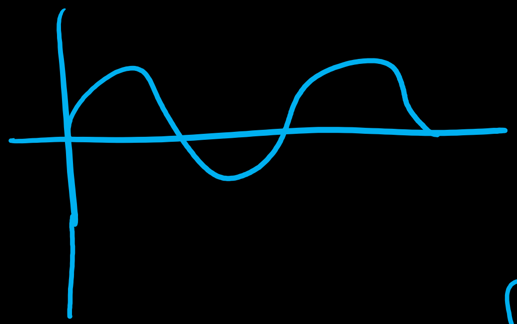
$L = \frac{1\lambda}{2}$

$\boxed{\lambda = 2L}$

$f = 40\text{Hz}$

$V = 2(40)(2\text{m})$

$V = 160\text{ms}^{-1}$



$L = \frac{n\lambda}{2}$

$\lambda = \frac{2L}{n}$

$V = f\lambda$

$\lambda \propto f$

$\lambda_{new} = \frac{\lambda_{old}}{n}$

$f_{new} = n(f_{old})$

$n = \frac{f_{new}}{f_{old}}$

$= \frac{160}{40}$

$n = 4.$

$\frac{1}{8}$

$L_{pluck} = \frac{1}{8}(2)$

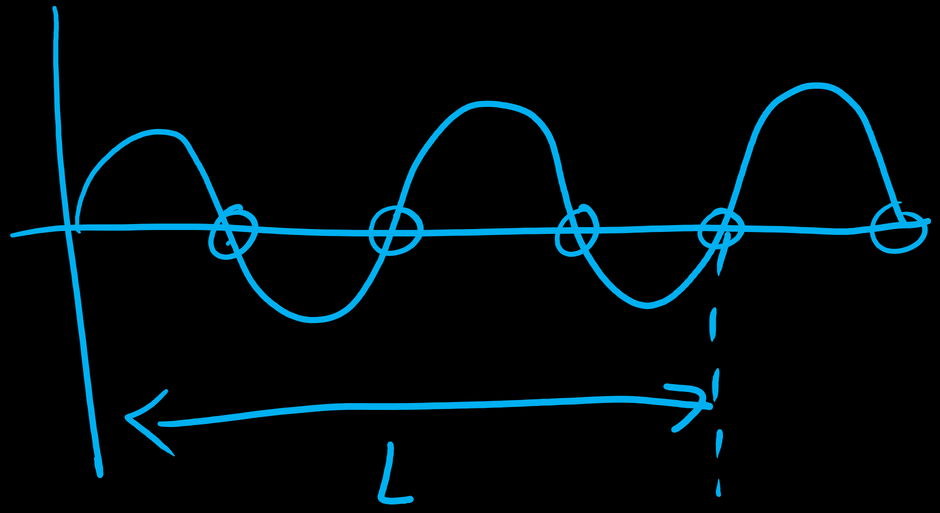
$\approx 0.25\text{m}$

PSPM 0506

A 2 m taut string is plucked at its centre producing vibrations with fundamental frequency of 40 Hz.

a. Calculate the velocity of the transverse wave propagating in the string.

b. At what position should the string be plucked to produce vibrations at frequency 160 Hz?



$L = 2\lambda$

4x the λ, placement of pluck will be $\frac{L}{4}$.

PSPM 0910

A progressive wave is represented by equation

$$y = 20\sin(150\pi t - 1.8x)$$

where y is the displacement in cm, t is time in second and x is the distance in meter. Calculate the wave velocity.

$y = A\sin(\omega t \pm kx)$

$y = 20\sin(150\pi t - 1.8x)$

$\omega = 150\pi$

$k = 1.8\ \text{m}^{-1}$

$V = f\lambda$

$\omega(f) = 2\pi f$

$k(\lambda) = \frac{2\pi}{\lambda}$

$\frac{150\pi}{2\pi} = f$

$75\ \text{Hz} = f$

$1.8 = \frac{2\pi}{\lambda}$

$\lambda = \frac{2\pi}{1.8} = 3.49\ \text{m}$

$V = f\lambda$

$= 75(3.49)$

$\approx 261.75\ \text{ms}^{-1}$ #

Thank You!

5th October 2021

Learning Outcomes:

1. Define heat conduction
2. Solve problems related to rate of heat transfer, $\frac{dQ}{dt} = -kA\frac{dT}{dx}$, through a cross-sectional area. (Maximum 2 insulated objects in series)
3. Discuss temperature-distance, $T - x$ graph for for heat conduction through insulated and noninsulated rods. (Maximum two rods in series)
4. Define coefficient of linear, area and volume thermal expansion.
5. Solve problems related to thermal expansion of linear, area and volume (include expansion of liquid in a container):

$$\Delta L = \alpha L_o \Delta T; \;\beta = 2\alpha; \;\gamma = 3\alpha$$

Transfer of heat

thermal expansion

$\left\{ \begin{array}{l} Q = mc\theta \\ Q = mL \end{array} \right\} \Leftarrow$ content

area of contact

$\left\{ \frac{dQ}{dt} = -kA\frac{dT}{dx} \right\} \Leftarrow$ rate of heat flow

material

temperature gradient

0

70 $\leftarrow \frac{dT}{dx}$ besar

0 5 cm 10 $\leftarrow \frac{dT}{dx}$ kecil

Learning Outcomes:

1. Define heat conduction

2. Solve problems related to rate of heat transfer, $\frac{dQ}{dt} = -kA\frac{dT}{dx}$, through a cross-sectional area. (Maximum 2 insulated objects in series)

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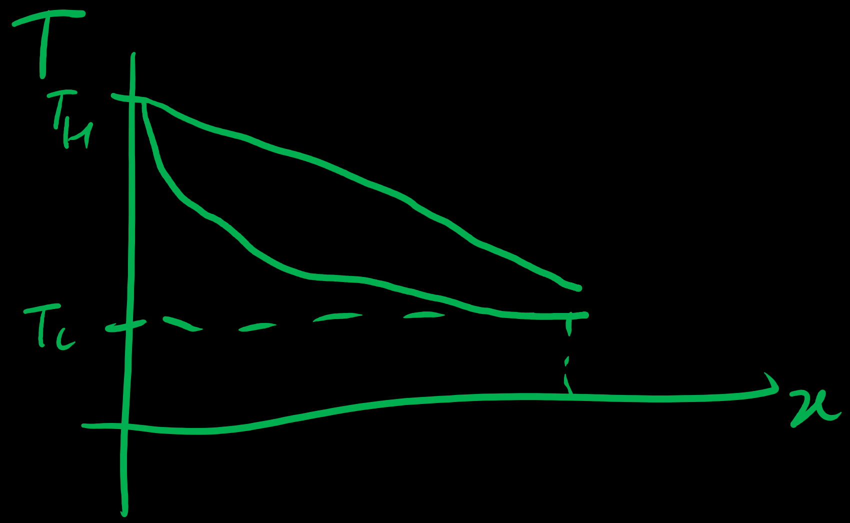

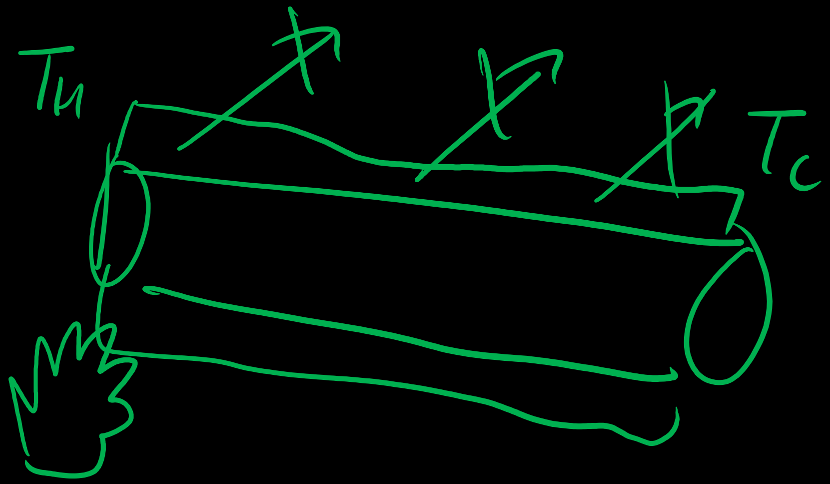

Learning Outcomes:

1. Define heat conduction
2. Solve problems related to rate of heat transfer, $\frac{dQ}{dt} = -kA\frac{dT}{dx}$, through a cross-sectional area. (Maximum 2 insulated objects in series)
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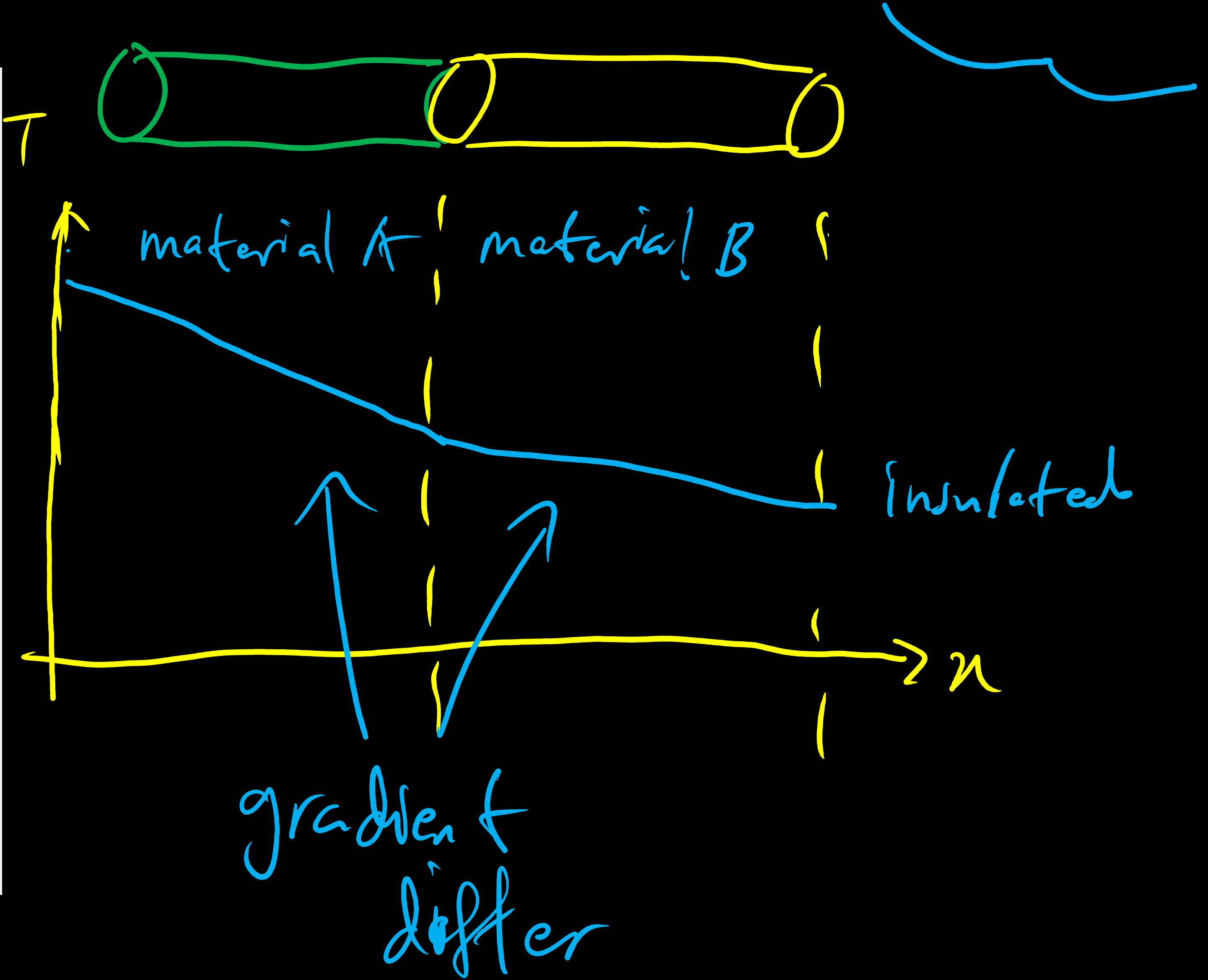

Learning Outcomes:

1. Define heat (conduction)
2. Solve problems related to rate of heat transfer, $\frac{dQ}{dt} = -kA\frac{dT}{dx}$, through a cross-sectional area. (Maximum 2 insulated objects in series)
3. Discuss temperature-distance, $T - x$ graph for for heat conduction through insulated and noninsulated rods. (Maximum two rods in series)
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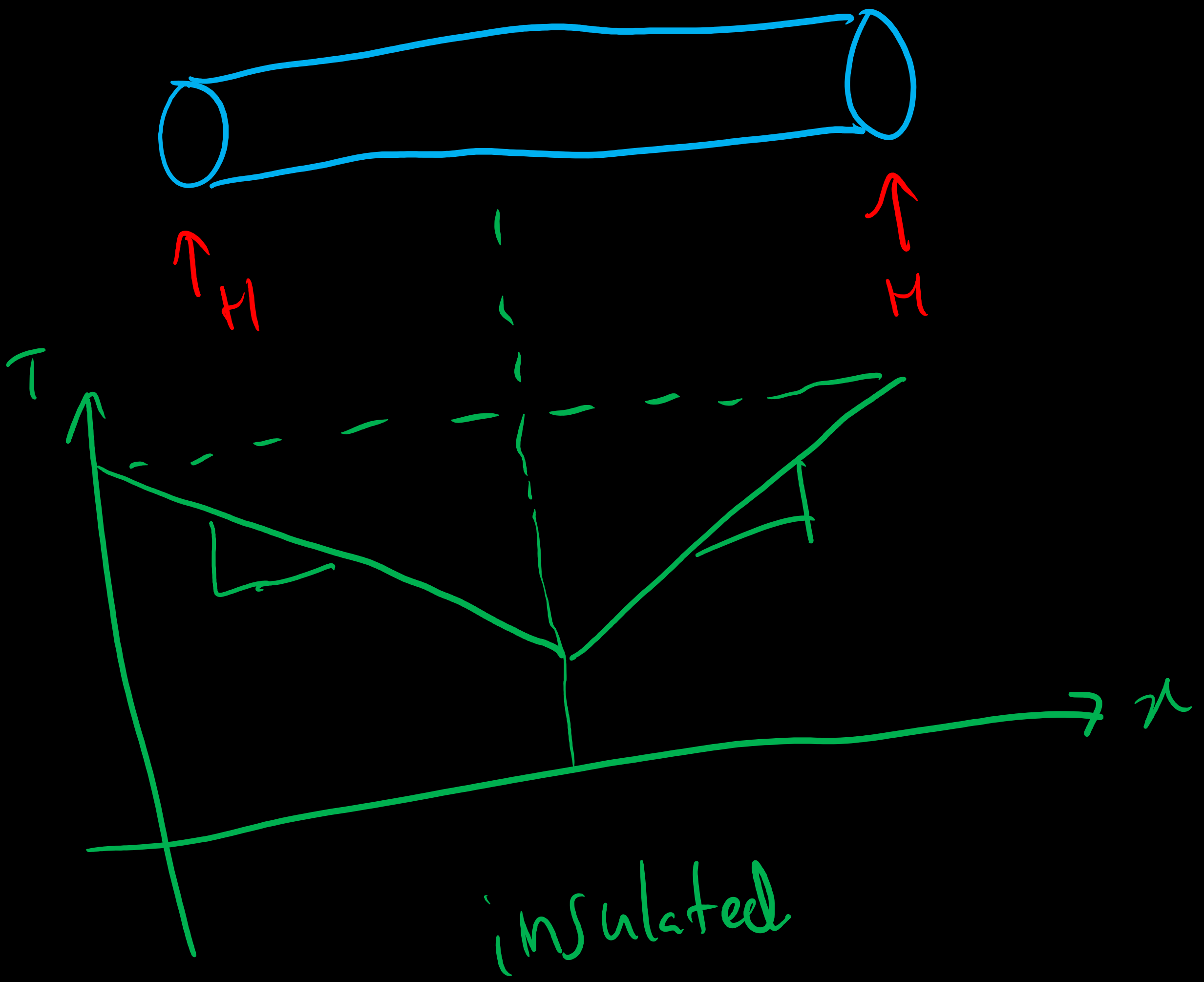

Learning Outcomes:

1. Define heat conduction
2. Solve problems related to rate of heat transfer, $\frac{dQ}{dt} = -kA\frac{dT}{dx}$, through a cross-sectional area. (Maximum 2 insulated objects in series)
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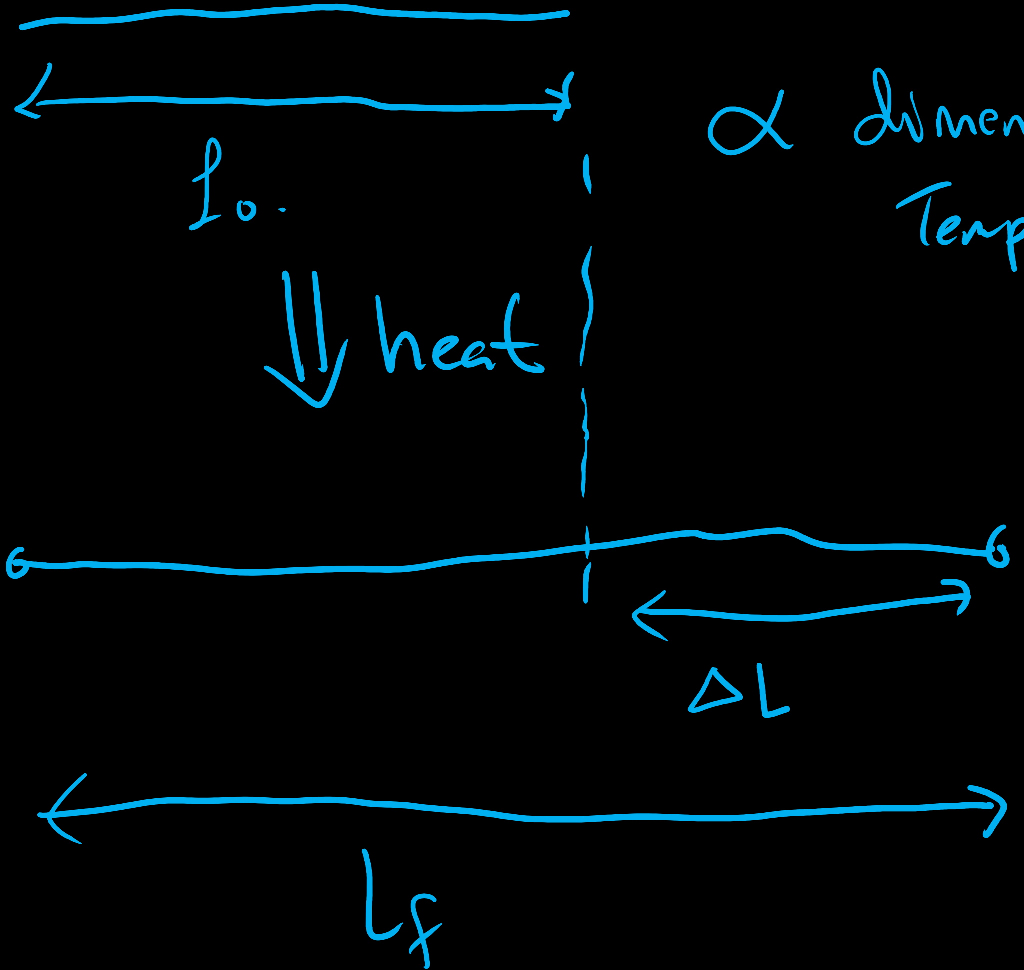
5. Solve problems related to thermal expansion of linear, area and volume (include expansion of liquid in a container):

$$\Delta L = \alpha L_o \Delta T;\ \beta = 2\alpha;\ \gamma = 3\alpha$$

$$\boxed{\Delta L = L_f - L_o}$$

$$\frac{\Delta L}{\Delta T}\left(\frac{1}{L_o}\right) = \alpha$$

α dimension Temp



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4. Define coefficient of linear, area and volume thermal expansion.
5. Solve problems related to thermal expansion of linear, area and volume (include expansion of liquid in a container):

$$\Delta L = \alpha L_o \Delta T; \; \underset{\text{area}}{\beta} = 2\alpha; \; \underset{\text{volumetric}}{\gamma} = 3\alpha$$

$$\beta = \frac{\Delta A}{\Delta T}\left(\frac{1}{A_0}\right)$$

$$\gamma = \frac{\Delta V}{\Delta T}\left(\frac{1}{V_0}\right)$$

Coefficient of volumetric thermal expansion, $\beta = 3\alpha$

where

α is coefficient of linear thermal expansion.

Learning Outcomes:

1. Define heat conduction
2. Solve problems related to rate of heat transfer, $\frac{dQ}{dt} = -kA\frac{dT}{dx}$, through a cross-sectional area. (Maximum 2 insulated objects in series)
3. Discuss temperature-distance, $T - x$ graph for for heat conduction through insulated and noninsulated rods. (Maximum two rods in series)
4. Define coefficient of linear, area and volume thermal expansion.
5. Solve problems related to thermal expansion of linear, area and volume (include expansion of liquid in a container):

$$\Delta L = \alpha L_o \Delta T;\ \beta = 2\alpha;\ \gamma = 3\alpha$$

$$\frac{dQ}{dt} = -kA\frac{dT}{dx}$$

$$= -kA\left(\frac{T_H - T_C}{L}\right)$$

L = length of rod

T_H = temp @ hot end

T_C = temp @ cold end

k = thermal conductivity

A = contact area

Learning Outcomes:

1. Define heat conduction
2. Solve problems related to rate of heat transfer, $\frac{dQ}{dt} = -kA\frac{dT}{dx}$, through a cross-sectional area. (Maximum 2 insulated objects in series)
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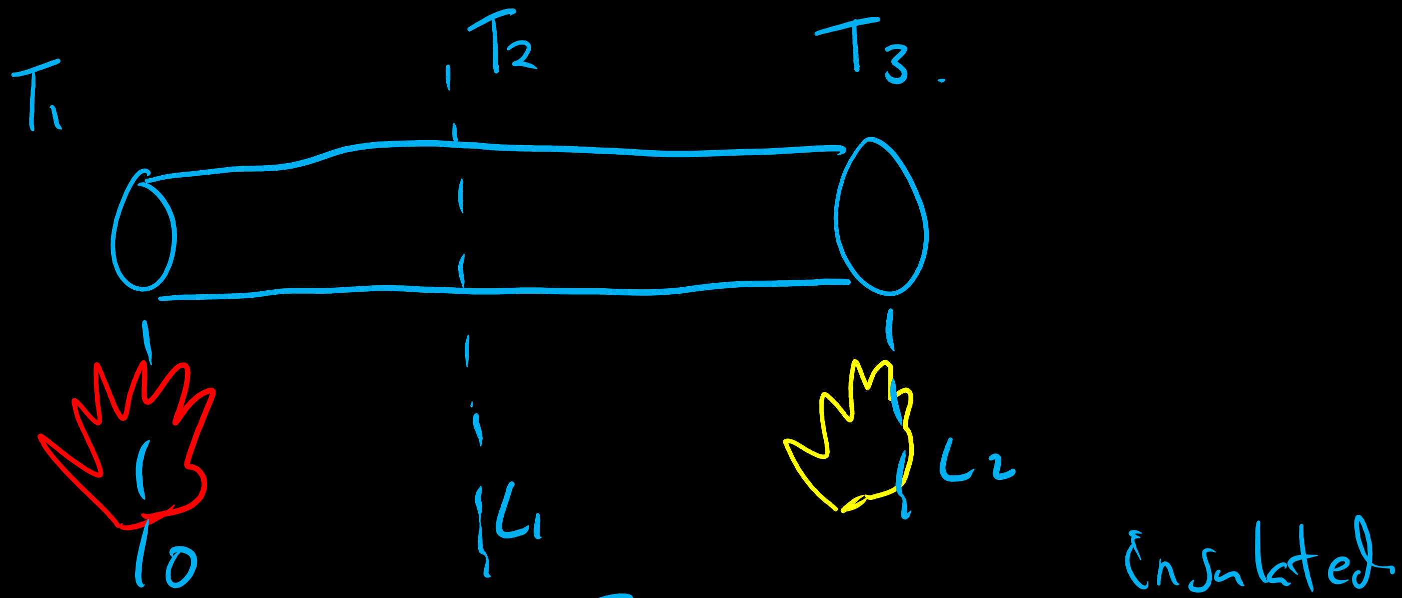
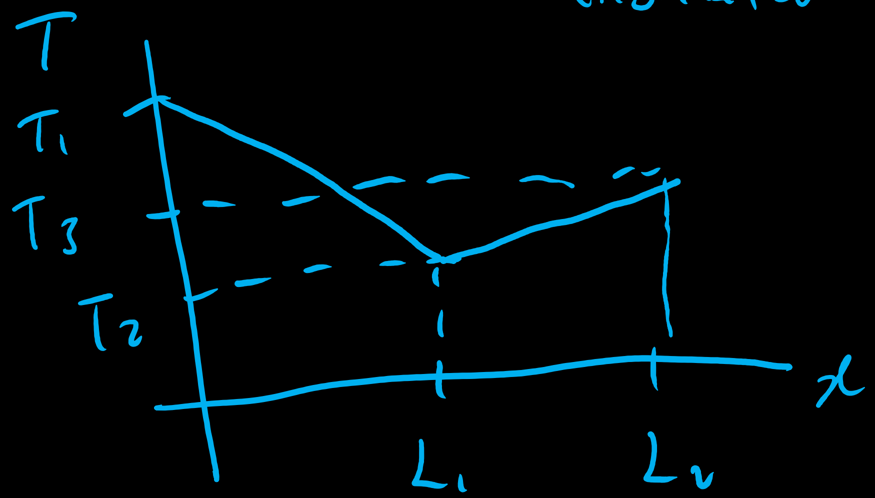


$T_1 > T_3$.

$T_3 > T_2$.

$T: T_1 > T_3 > T_2$.



12.1 — Q2
12.2 — Q1 $\Big\}$ solution + explanation

Learning Outcomes:

1. Define heat conduction
2. Solve problems related to rate of heat transfer, $\frac{dQ}{dt} = -kA\frac{dT}{dx}$, through a cross-sectional area. (Maximum 2 insulated objects in series)
3. Discuss temperature-distance, $T - x$ graph for for heat conduction through insulated and noninsulated rods. (Maximum two rods in series)
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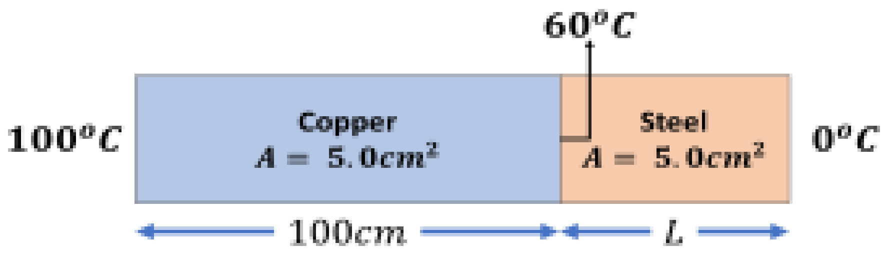
$$\Delta L = \alpha L_o \Delta T;\ \beta = 2\alpha;\ \gamma = 3\alpha$$

Thank you!

8th October 2021

steady state

2. The figure below shows a steady temperature condition.

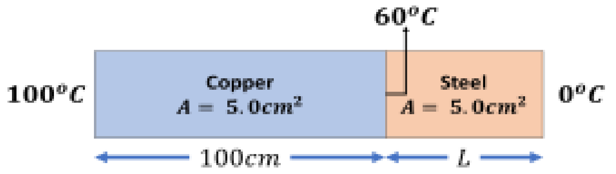


If the thermal conductivity for Copper and steel is 380 $Wm^{-1}K^{-1}$ and 46 $Wm^{-1}K^{-1}$ respectively, determine:

a) The length, L of the steel rod

b) The rate of heat flow through both rods.

2. The figure below shows a steady temperature condition.



If the thermal conductivity for Copper and steel is 380 $Wm^{-1}K^{-1}$ and 46 $Wm^{-1}K^{-1}$ respectively, determine:

a) The length, L of the steel rod

b) The rate of heat flow through both rods.

---

(2) 100 cm, L, Copper, steel, 100°C, 0°C, 60°C, A = 5.0 cm², A = 5.0 cm²

$k_c = 380\ Wm^{-1}K^{-1}$

$k_s = 46\ Wm^{-1}K^{-1}$

$T_c = 100 - 60 = 40°C$

$T_s = 60 - 0 = 60°C$

Full mark

a) length steel rod

$\left(\frac{dQ}{dt}_c = \frac{dQ}{dt}_s\right)$ ← Steady state condition

$-kA\frac{dT}{dx} = -kA\frac{dT}{dx}$

$(380)(5.0)\left(\frac{40}{1}\right) = (46)(5.0)\left(\frac{60}{L}\right)$

$76000 = 230\left(\frac{60}{L}\right)$

$L = 0.182\ m$

Ain no problem

Zafirah → ~~A not in m²~~ → ~~temp ≠ K~~

b) $\frac{Q}{t} = kA\frac{\Delta T}{L}$

$= \frac{(\cancel{380+46})(0.05)(20)}{(1 + 0.182)}$

$= \frac{426}{1.182}$

$= \cancel{360.41}\ W$

7.6W

tak boleh tambah $k_{cu} + k_s$

$-k_{cu}\cancel{A_{cu}}\frac{\Delta T}{\Delta x} = -k_s\cancel{A_s}\frac{\Delta T}{\Delta x}$

$A_{cu} = A_s = A$

$\boxed{\Delta T_K = \Delta T_{°C}}$

$\boxed{\uparrow 1°C = \uparrow 1K}$

$\frac{dQ_T}{dt} = \frac{dQ_{cu}}{dt} = \frac{dQ_s}{dt}$

2. $T = 100 + 273.15$

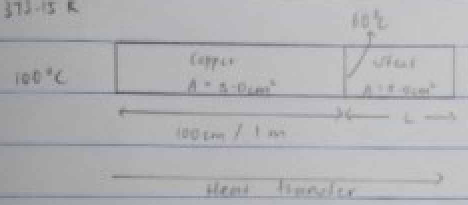
$T = 373.15\ K$

$T = 60 + 273.15$

$T = 333.15\ K$

$T = 0 + 273.15$

$T = 273.15\ K$



$A = 5 \times 10^{-4}\ m^2$

$k_c = 380\ W\,m^{-1}\,K^{-1}$

$k_s = 46\ W\,m^{-1}\,K^{-1}$

(a) Steady temperature condition means no heat loss. Thus,

$$\left(\frac{dQ}{dt}\right)_c = \left(\frac{dQ}{dt}\right)_s$$

Rate of heat transfer equation: $\frac{dQ}{dt} = -kA\frac{dT}{dx}$

$$-k_c A\left(\frac{dT}{dx}\right)_c = -k_s A\left(\frac{dT}{dx}\right)_s$$

Rearrange for dx_s:

$$dx_s = \frac{-k_s\, dT_s\, dx_c}{-k_c\, dT_c}$$

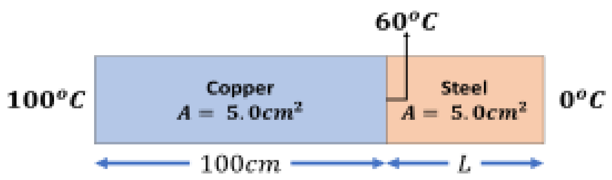
$$L = \frac{-(46)(273.15 - 333.15)(1)}{-(380)(333.15 - 373.15)}$$

$$L = \frac{69}{380}$$

$$L \simeq 0.1816\ m$$

$\boxed{L = 0.1816m}$

2. The figure below shows a steady temperature condition.

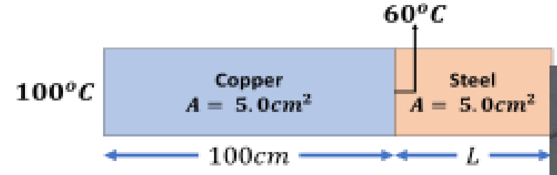


If the thermal conductivity for Copper and steel is 380 $Wm^{-1}K^{-1}$ and 46 $Wm^{-1}K^{-1}$ respectively, determine:

a) The length, L of the steel rod

b) The rate of heat flow through both rods.

2. The figure below shows a steady temperature condition.



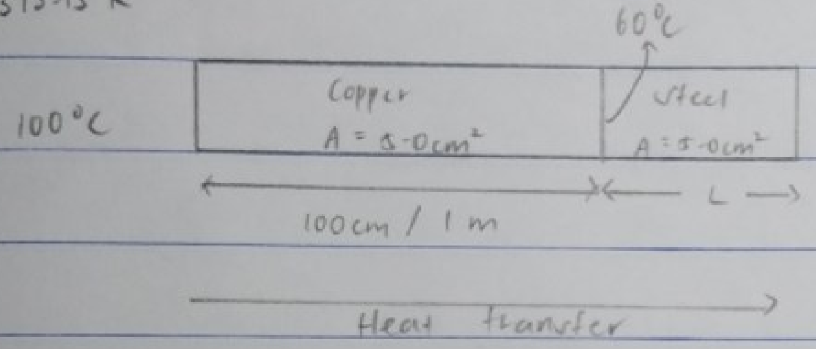
If the thermal conductivity for Copper and steel is 380 $Wm^{-1}K^{-1}$

2.

$T = 60 + 273.15$
$T = 333.15\ K$

$T = 100 + 273.15$
$T = 373.15\ K$

$T = 0 + 273.15$
$T = 273.15\ K$



$A = 5 \times 10^{-4}\ m^2$

$k_c = 380\ W m^{-1} K^{-1}$

$k_s = 46\ W m^{-1} K^{-1}$

(a) Steady temperature condition means no heat loss. Thus,

$$\left(\frac{dQ}{dt}\right)_c = \left(\frac{dQ}{dt}\right)_s$$ K1

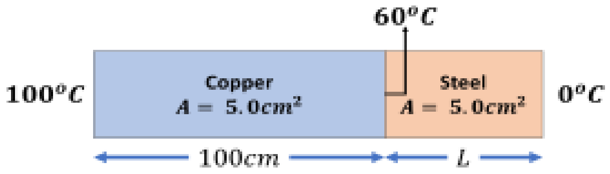
Rate of heat transfer equation: $\frac{dQ}{dt} = -kA\frac{dT}{dx}$

$\frac{dQ}{dt}$
Q
t = time
k = thermal ~
A

dT = change in
dx

$$-k_c A\left(\frac{dT}{dx}\right)_c = -k_s A\left(\frac{dT}{dx}\right)_s$$

2. The figure below shows a steady temperature condition.



If the thermal conductivity for Copper and steel is 380 $Wm^{-1}K^{-1}$ and 46 $Wm^{-1}K^{-1}$ respectively, determine:

a) The length, L of the steel rod

b) The rat
both rods.

$$\frac{dT}{dx} \rightarrow \frac{\Delta T}{\Delta x}$$

$\boxed{\frac{dT}{dx}}$ => not fraction

$\frac{\Delta T}{\Delta x}$ => ✓ fraction

$$-k_c \cancel{A} \boxed{\left(\frac{dT}{dx}\right)_c} = -k_s \cancel{A} \left(\frac{dT}{dx}\right)_s$$

Rearrange for dx_s :

$$dx_s = \frac{-k_s\, dT_s\, \Delta x_c}{-k_c\, \Delta T_c}$$

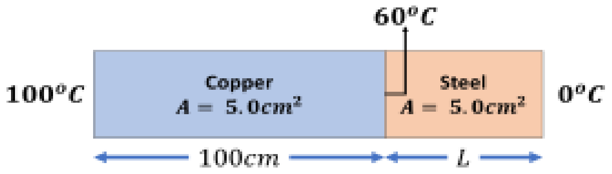
$$L = \frac{-(46)(273.15-333.15)(1)}{-(380)(333.15-373.15)}$$

$$L = \frac{69}{380}$$

$$L \simeq 0.1816\,m$$

full marks

2. The figure below shows a steady temperature condition.



If the thermal conductivity for Copper and steel is 380 $Wm^{-1}K^{-1}$ and 46 $Wm^{-1}K^{-1}$ respectively, determine:

a) The length, L of the steel rod

b) The rate of heat flow through

(b) The rate of heat flow through both rods is the same as they are [illegible] a steady temperature condition.

$$\left(\frac{dQ}{dt}\right)_c = \left(\frac{dQ}{dt}\right)_s$$

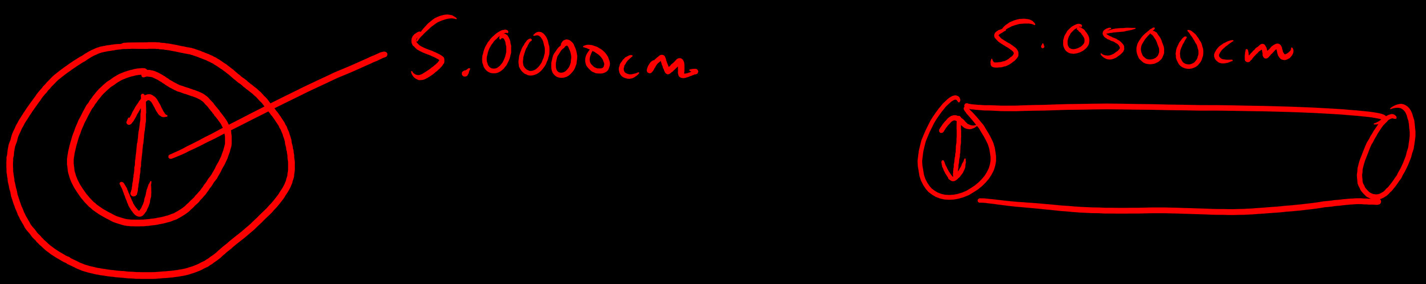
$$\frac{dQ_T}{dt}$$

$$-k_c A \left(\frac{dT}{dx}\right)_c = -k_s A \left(\frac{dT}{dx}\right)_s$$

$$-380(5\times10^{-4})\left(\frac{333.15-373.15}{1}\right) = -46(5\times10^{-4})\left(\frac{273.15-333.15}{150}\right)$$

$$\frac{dQ_T}{dt} \; \cancel{2dm} = 7.6\text{ W}$$

∴ The rate of heat flow through both rods is 7.6 W.



$\Delta d \simeq 0.05$ cm

1. At 20 ^oC, an aluminium ring has an inner diameter of 5.0000 cm and a brass rod has a diameter of 5.0500 cm. ($\alpha_{Al} = 4 \times 10^{-6o}C^{-1}$, $\alpha_{brass} = 19 \times 10^{-6o}C^{-1}$)

   a) If only the ring is warmed, what temperature must it reach so that it will just slip over the rod?

   b) What if? If both the ring and the rod are warmed together, what temperature must they both reach so that the ring barely slips over the rod?

   c) Would this latter process work? Explain?

Lin = no prob.

Joseph : no problem

Zafrul : tahde

1. At 20 ^oC, an aluminium ring has an inner diameter of 5.0000 cm and a brass rod has a diameter of 5.0500 cm. ($\alpha_{Al} = 4 \times 10^{-6} {}^oC^{-1}$, $\alpha_{brass} = 19 \times 10^{-6} {}^oC^{-1}$)

   a) If only the ring is warmed, what temperature must it reach so that it will just slip over the rod?

   b) What if? If both the ring and the rod are warmed together, what temperature must they both reach so that the ring barely slips over the rod?

   c) Would this latter process work? Explain?

12.2 Thermal Expansion

1. $L_o = 5.000\,cm$, $L = 5.050\,cm$, $T_o = 20°C$, $\alpha_{Al} = 4\times10^{-6}\,°C^{-1}$, $\alpha_{brass} = 19\times10^{-6}\,°C^{-1}$

Thermal expansion formula

$$\frac{\Delta L}{L_o} = \alpha \Delta T$$

$$\Delta L = L_o \alpha \Delta T$$

$$L = L_o + \Delta L$$

$$= L_o + L_o \alpha \Delta T$$

$$= L_o [1 + \alpha \Delta T]$$

$$L = L_o [1 + \alpha \Delta T]$$

$$L = L_o [1 + \alpha (T - T_o)]$$

$$\frac{L}{L_o} = 1 + \alpha (T - T_o)$$

$$T - T_o = \frac{L/L_o - 1}{\alpha}$$

$$T = \frac{L/L_o - 1}{\alpha} + T_o$$

$$T = \frac{5.050/5.000 - 1}{24\times10^{-6}} + 20$$

$$= 436.67°C$$

if use $4(10^{-6})$

$$\boxed{T = \cancel{436}.\ 2520\,°C}$$

$\alpha_{al} = 4 \mu °C^{-1}$

$10^{-6} = \mu$

1. At 20 ^oC, an aluminium ring has an inner diameter of 5.0000 cm and a brass rod has a diameter of 5.0500 cm. ($\alpha_{Al} = 4 \times 10^{-6o}C^{-1}$, $\alpha_{brass} = 19 \times 10^{-6o}C^{-1}$)

   a) If only the ring is warmed, what temperature must it reach so that it will just slip over the rod?

   b) What if? If both the ring and the rod are warmed together, what temperature must they both reach so that the ring barely slips over the rod?

   c) Would this latter process work? Explain?

b) $L_{Al} = L_{Brass}$

$L_0(1+\alpha\Delta T) = L_0(1+\alpha\Delta T)$

$L_0 + \alpha\Delta T L_0 = L_0 + \alpha\Delta T L_0$

$5.000 + (4\times10^{-6})(5.000)\Delta T = 5.050 + (19\times10^{-6})(5.050)\Delta T$

$5.000 + 1.2\times10^{-4}\Delta T = 5.050 + 9.595\times10^{-5}\Delta T$

$2.405\times10^{-5}\Delta T = 0.050$

$\Delta T = 2079°C$

$\boxed{638.328°C}$

N

c) No because Aluminium melt at 660°C while brass (an alloy of copper and zinc) melt at 900°C based on internet research.

$$T = \frac{\frac{\Delta L}{L} - 1}{\alpha} + T_0$$

1. At 20 ^oC, an aluminium ring has an inner diameter of 5.0000 cm and a brass rod has a diameter of 5.0500 cm. ($\alpha_{Al} = 4 \times 10^{-6} {}^oC^{-1}$, $\alpha_{brass} = 19 \times 10^{-6} {}^oC^{-1}$)
   a) If only the ring is warmed, what temperature must it reach so that it will just slip over the rod?
   b) What if? If both the ring and the rod are warmed together, what temperature must they both reach so that the ring barely slips over the rod?
   c) Would this latter process work? Explain?

according to question

$\alpha = 4 \times 10^{-6}\ {}^\circ C^{-1}$

⋮

$T = 2520\,^\circ C$

However, internet research tells me $\alpha_{Al} \simeq 24 \times 10^{-6}\ {}^\circ C^{-1}$

this leads to

⋮

$T = 436.67\,^\circ C$.

Thank you.

18 October 2021

Chapter 13 Review

Time allocation:
1.5h (Lecture) + 4h (Tutorial)
Learning Outcomes:

1. Solve problems related to ideal gas equation, $pV = nRT$.

2. Discuss the following graphs of an ideal gas:

    - p-V graph at constant temperature
    - V-T graph at constant pressure
    - p-T graph at constant volume

3. State the assumptions of kinetic theory of gases.

4. Discuss root mean square (rms) speed of gas molecules

5. Solve problems related to root mean square (rms) speed of gas molecules.

6. Solve problems related to the equations:

$$pV = \frac{1}{3}Nmv_{rms}^2;\ p = \frac{1}{3}\rho v_{rms}^2$$

7. Discuss translational kinetic energy of a molecule, $K_{tr} = \frac{3}{2}\left(\frac{R}{N_A}\right)T = \frac{3}{2}k_BT$

8. Discuss degrees of freedom, f for monoatomic, diatomic and polyatomic gas molecules.

9. State the principle of equipartition of energy.

10. Discuss internal energy of gas.

11. Solve problems related to internal energy, $U = \frac{1}{2}fNk_BT$

1. Solve problems related to ideal gas equation, $pV = nRT$.
2. Discuss the following graphs of an ideal gas:
   - p-V graph at constant temperature
   - V-T graph at constant pressure
   - p-T graph at constant volume
3. State the assumptions of kinetic theory of gases.

$$\boxed{\frac{pV}{T}} = \boxed{nR}$$

big picture

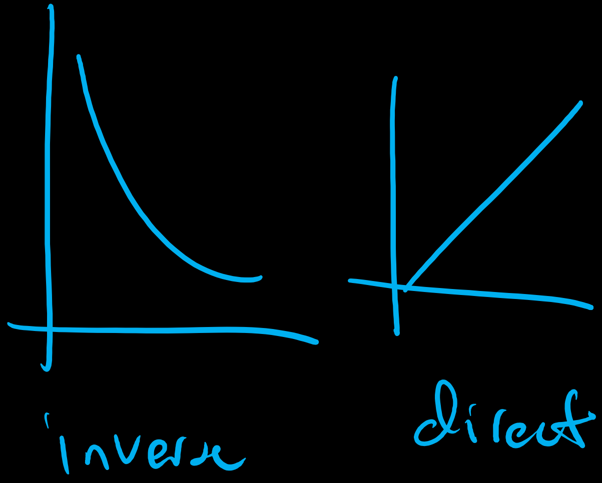
small picture

k_B, N_A

$$\frac{pV}{T} = \text{constant}$$

$$p = \frac{\text{constant}}{V}$$

$$p \propto \frac{1}{V}$$



LO3:

assumption k.t.g

# of particles?

collide?

mass?

big/small?

$$\frac{P}{T} = \frac{nR}{V} = \text{constant}$$

$$\Delta\left(\frac{P}{T}\right) = 0$$

$$\left(\frac{P}{T}\right)_f - \left(\frac{P}{T}\right)_i = 0$$

$$\frac{P_f}{T_f} = \frac{P_i}{T_i}$$

4. Discuss root mean square (rms) speed of gas molecules

5. Solve problems related to root mean square (rms) speed of gas molecules.

6. Solve problems related to the equations:

small to big

$$pV = \frac{1}{3}Nmv_{rms}^2; \; p = \frac{1}{3}\rho v_{rms}^2$$

7. Discuss translational kinetic energy of a molecule, $K_{tr} = \frac{3}{2}\left(\frac{R}{N_A}\right)T = \frac{3}{2}k_BT$

Small picture

$\frac{1+(-1)}{2}$ = average

$\frac{0}{2} = 0$ = average

$\sqrt{1^2+(-1)^2} = \sqrt{2}$

⇒ takes away the factor of direction

$\sqrt{v^2}$

why not take average?

$1\,ms^{-1}$ $1\,ms^{-1}$

$pV = \frac{1}{3}Nm v_{rms}^2$

big small

$\rho = \frac{Nm}{V}$

small

$p = \frac{1}{3}\rho v_{rms}^2$

4. Discuss root mean square (rms) speed of gas molecules

5. Solve problems related to root mean square (rms) speed of gas molecules.

6. Solve problems related to the equations:

$$pV = \frac{1}{3}Nmv_{rms}^2;\ p = \frac{1}{3}\rho v_{rms}^2$$

7. Discuss translational kinetic energy of a molecule, $K_{tr} = \frac{3}{2}\left(\frac{R}{N_A}\right)T = \frac{3}{2}k_B T$

$$pV = \frac{1}{3}\,N\,m\,v_{rms}^2$$

Choose 1 of 3 dimension x, y or z

# of particles ~~hitting~~ hitting the wall

how hard ~~#~~ they hit the wall.

$$K_{tr} = \frac{3}{2}k_B T$$

Boltzmann constant

$$K_{tr}(T)$$

8. Discuss degrees of freedom, f for monoatomic, diatomic and polyatomic gas molecules.

9. State the principle of equipartition of energy.

10. Discuss internal energy of gas.

11. Solve problems related to internal energy, $\boxed{U = \frac{1}{2} f N k_B T}$

D.O.F

$$E_{tr} = \frac{1}{2} m \boxed{v^2}$$

$$E_{rot} = \frac{1}{2} I \omega^2$$

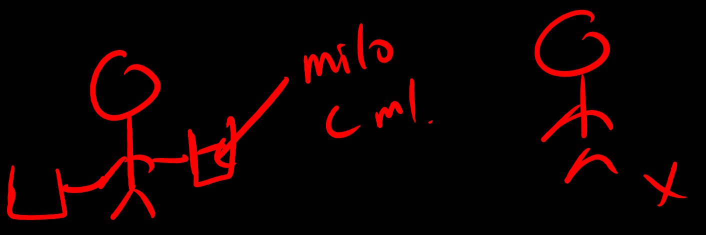
$$E_{ep} = \frac{1}{2} k x^2$$

Log:

$$1 \text{ DOF} \Rightarrow \frac{1}{2} k_B T$$

(internal)

$$U_T = \underbrace{\left(\frac{1}{2} k_B T\right)}_{\text{1 particle per DOF}} (\underbrace{f}_{\text{\# DOF per particle}} \underbrace{N}_{\text{\# of particle}})$$



× N people.

$$\text{Total milo} = \underbrace{2}_{\text{\# of arms per person}} \times \underbrace{N}_{\text{\# of people}} \times \underbrace{c}_{\text{amount of milo per arm per person}}$$

Thank you!

19 October 2021

Chapter 13 Sample Problems

1. A gas of volume 2.5 litres at temperature 30^oC and pressure 1 atm is expanded until its volume is 3.0 $litres$ and the pressure is 1.5atm. Determine

   a) the number of mole of the gas

   b) the final temperature of the gas

$\Delta V = 0.5L$

$\cancel{P = 1.5}$

$\Delta P = 0.5atm$

$T = 30°c$

$\left| \frac{pV}{T} \right| = nR$

Jeso

Applying

Konsep

$\Delta\left(\frac{pV}{T}\right) = 0$

From Ideal gas Law,

1a) $pV = nRT$

$1atm = 101325 Pa$

$1.5atm = 151987.5 Pa$

$1L = 1000cm^3 = 1\times10^{-3}m^3$

$3L = 3\times10^{-3}m^3$

$T = (30+273)°$

$T = 303K$

$(101325)(2.5\times10^{-3}) = n(8.314)(303)$

P_i V_i $n = 0.1006 mol$

using values given in its initial state

b) From Ideal gas Law,

$pV = nRT$

$T = \frac{pV}{nR}$ $\qquad \frac{P_f V_f}{nR}$

$$\left(\frac{pV}{T}\right)_i = \left(\frac{pV}{T}\right)_f$$

$T = \frac{(151987.5)(3\times10^{-3})}{(0.1006)(8.314)}$

$T = 545.16K$ ✓

$T_f = (545.16-273)°c$

$T_f = 272.16°c$ ∴ Final temperature of the gas $= 272.16°c$

2. Two identical cylinders A and B which are at the same pressure contain the same gas. If the number of mole of gas in cylinder A is three times to that of cylinder B, what is the temperature of A relative to B?

2.	$n_B = \frac{1}{3} n_A$	$\frac{T_A}{T_B} = \frac{1}{3}$ ⇐ statement
2	$n_A T_A = n_B T_B$	$T_A : T_B$ ratio
	$n_A T_A = \frac{1}{3} n_A T_B$	$1 : 3$

$pV = nRT$

$\frac{pV}{R} = nT = \text{constant}$

$3T_A = T_B$

$\boxed{T_B = 3T_A.}$

2. The molar mass of oxygen is 32 $gmol^{-1}$. At 370 K, find

a) the root mean square speed of the oxygen molecules,

b) the internal energy of 5 moles of oxygen.

$M = mu$

$\nu = nu$

V_{rms}

$V_{rms} = \sqrt{\frac{3RT}{n}}$

$\boxed{V_{rms}^2 = \frac{3RT}{n}}$

where?

equipartition theorem

$k_B \Rightarrow$ # of moles

$\Rightarrow$ # of particles

HW

2. molar mass of O = 32 $gmol^{-1}$ T = 370K

(a) rms?

R T

$$\mu_{rms} = \sqrt{\frac{3(8.3145)(370)}{(0.032\ kg\ mol^{-1})}}$$

n

$= 537.037\ ms^{-1}$

(b) the internal energy of 5 moles of oxygen.

$$U = \frac{3}{2} nRT$$

$$= \frac{3}{2}(5)(8.3145)(370)$$

$= 23072.7\cancel{38}\ J$

Thank you!

20 October 2021

Sample Problems 13.2 & 13.3

2. The molar mass of oxygen is 32 $g mol^{-1}$. At 370 K, find

a) the root mean square speed of the oxygen molecules,

b) the internal energy of 5 moles of oxygen.

DOF : 3

translational kinetic energy

x, y, z axis

5 DOF

≠ { Total kinetic energy }

3 — translational

+

2 — rotational

$\boxed{\text{+ vibrational}}$

Ek — translational Ek, 3 DOF

— rotational kinetic energy, 2 DOF

— vibrational Ek, 2 DOF

proceed with caution.

1. A vessel contains an ideal polyatomic gas at temperature of $30\ ^oC$. The total translational kinetic energy of the gas molecules is $6.00 \times 10^6\ J$. The mass of the gas is then doubled and the total translational kinetic energy of the molecules becomes $13.00 \times 10^6\ J$. Determine the new temperature of the gas.

DOF

3

$M_{new} = (M_{old})2$

13.3

unit consistent

1. $T_0 = 30 + 273 = 303\ K$ | $R = 8.31\ J\ K^{-1}\ mol^{-1}$

polyatomic gas $\boxed{f = 6}$

$\boxed{\Delta m \neq 0}$

$E_0 = 6 \times 10^6\ J$

$E_f = 13 \times 10^6\ J$

1. A vessel contains an ideal polyatomic gas at temperature of 30 ^oC. The total translational kinetic energy of the gas molecules is $6.00 \times 10^6\,J$. The mass of the gas is then doubled and the total translational kinetic energy of the molecules becomes $13.00 \times 10^6\,J$. Determine the new temperature of the gas.

$2 \times$ mass

$\Downarrow$

$\Delta E_k \neq 0$.

$$\boxed{E_0 = \frac{1}{2} f n R T}$$

$E_{Th}\,(T)$

$$6 \times 10^6 = \frac{1}{2}(6)\,n\,(8.31)(303)$$

$$n = 794.303 \text{ mol}$$

Wrong!

$$E_f = \frac{1}{2} f n R T$$

mass not the same.

$$13 \times 10^6 = \frac{1}{2}(6)(794.303)(8.31)\,T$$

refer next slide

$$T = 656.5\,K$$

1. A vessel contains an ideal polyatomic gas at temperature of 30 ^oC. The total translational kinetic energy of the gas molecules is $6.00 \times 10^6 J$. The mass of the gas is then doubled and the total translational kinetic energy of the molecules becomes $13.00 \times 10^6 J$. Determine the new temperature of the gas.

	initial	final	
mass	m_{old}	$m_{new} = 2m_{old}$	
E_{kT} ($\times 10^6 J$)	6	13	
~~Temp (°C)~~ Temp (K)	~~373~~ 303	T_{final}	

1. A vessel contains an ideal polyatomic gas at temperature of 30 ^oC. The total translational kinetic energy of the gas molecules is $6.00 \times 10^6 J$. The mass of the gas is then doubled and the (total translational kinetic energy) of the molecules becomes $13.00 \times 10^6 J$. Determine the new temperature of the gas.

mass changes $\Rightarrow$ # of mole will also change

DOF = 3.

Ans: $328K \simeq T_{new}$

2. An ideal gas has 6 degrees of freedom at 40 ^oC. Calculate

a) the kinetic energy of the gas molecule

b) the total energy in one mole of gas.

1 mole = N_A molecule

n mole = $n N_A$ molecule

$N = n N_A$; $R = k_B N_A$

N = number of molecule

1 molecule

$$U = \frac{f}{2} N k_B T = \frac{f}{2} n R T$$

# of molecule

# of mole

$$= \frac{f}{2} n k_B N_A T$$

2. An ideal gas has 6 degrees of freedom at 40°c Calculate

(a) ~~kinety~~ ~~on~~ kinetic energy of the gas molecule.

$$U = \frac{1}{2} f N kT$$

$$= \frac{1}{2}(6)(1)(1.38$$

$$= 1.297 \times 10^{-20}$$

mana conversion

(b) the total energy in on

$$U = \frac{1}{2} f N R T$$

$$= \frac{1}{2}(6)(1)(8.314)(313.15)$$

$$= 7810.58 \text{ k}$$

3. A container is filled with 4 moles of hydrogen gas at 25 ^oC. Calculate:

a) Translational kinetic energy of hydrogen molecules

b) Total translational kinetic energy of hydrogen gas

c) Average kinetic energy of hydrogen gas.

d) Internal energy of hydrogen gas.

1 molecule.

DOF

tunjuk conversion

(ada tapi tatal)

$U = \frac{f}{2} nRT$ (4 mole)

$U = \frac{f}{2} N k_B T$

$N = 1$

(a) $K_{tr} = \boxed{\frac{3}{2} k_B T}$ ← general ✓

$K_{tr} = \frac{3}{2}(1.38 \times 10^{-23})(298.15)$

$K_{tr} \approx 6.172 \times 10^{-21}$ J ✓

(b) (Total (translational) kinetic energy):

$= \frac{3}{2} nRT$ → DOF = 3

$= \frac{3}{2}(4)(8.31)(298.15)$

$\approx 1.487 \times 10^{4}$ J

3. A container is filled with 4 moles of hydrogen gas at 25 ^oC. Calculate:

a) Translational kinetic energy of hydrogen molecules

b) Total translational kinetic energy of hydrogen gas

c) Average kinetic energy of hydrogen gas.

d) Internal energy of hydrogen gas.

Kenapa DOF = 5

Sebab wording 'kinetic energy'

K_{tr} DOF = 3 + $K_{rot.}$ DOF = 2 → 5

(c) $KE_{ave} = \frac{f}{2} nRT$

$KE_{ave} = \frac{5}{2}(4)(8.31)(298.15)$

$KE_{ave} \approx 24776$ J

(d) $U = \frac{f}{2} nRT$

$U = \frac{5}{2}(4)(8.31)(298.15)$

$U \approx 24776$ J

Thank you!

22nd October 2021

(a) A balloon is filled with helium at 25 ^oC. The mass of a helium atom is $6.65 \times 10^{-27}\ kg$. Calculate the

i. root mean square speed of the helium atom

ii. kinetic energy of $0.5 mol$ helium atom.

According to the Equipartition theorem, internal energy, $U = \frac{1}{2}k_B T$, for a molecule per degree of freedom.

$25^\circ C = T = 298 K.$

$M_{He} = 6.65(10^{-27})\,kg$

Considering 3 spatial dimension in which K_{tr} resides in, degrees of freedom $= 3$.

~~Consider~~ $\frac{1}{2}m\boxed{V_{rms}^2} = \frac{1}{2}k_B\boxed{T}(3)$. ---- [1]

Eq. [1] relates internal energy ~~from~~ to kinetic energy defined by V_{rms}.

(a) A balloon is filled with helium at 25 ^{o}C. The mass of a helium atom is $6.65 \times 10^{-27}\ kg$. Calculate the

i. root mean square speed of the helium atom

ii. kinetic energy of $0.5 mol$ helium atom.

Rearranging eq. [1];

$$V_{rms} = \sqrt{\frac{3k_B T}{m}}$$

where m is mass of molecule,

k_B is Boltzmann constant,

and T is temperature.

Substituting values : $k_B = 1.38(10^{-23})\ JK^{-1}$

$T = 298K$.

$m = 6.65(10^{-27})\ kg$

(a) A balloon is filled with helium at 25 ^oC. The mass of a helium atom is 6.65×10^{-27} kg. Calculate the

i. root mean square speed of the helium atom

ii. kinetic energy of $0.5mol$ helium atom.

$$\boxed{V_{rms} = \left[\frac{3(1.38\times10^{-23})(298)}{6.68(10^{-27})}\right]^{1/2}}$$

This yields

$$\boxed{V_{rms} = 1362 ms^{-1}}$$

~~The~~ The root mean square speed of the helium atom is $1362 ms^{-1}$

(a) A balloon is filled with helium at 25 ^oC. The mass of a helium atom is $6.65 \times 10^{-27}\ kg$. Calculate the

i. root mean square speed of the helium atom

ii. kinetic energy of $0.5 mol$ helium atom.

$n = 0.5$ mol

$K_{tr} = \frac{3}{2} k_B T$ from previous question

(for 1 molecule).

In 1 mole, there exist N_A particles

where, N_A = avogadro's constant

$N_A = 6.02 \times 10^{23}$

In n mole, then there are nN_A particles.

(N = number of particle) = $n N_A$

~~N~~ for $n = 0.5$,

$N = (0.5)(6.02)(10^{23})$ particles

$= 3.01 (10^{23})$ particles

(a) A balloon is filled with helium at 25 ^oC. The mass of a helium atom is 6.65×10^{-27} kg. Calculate the

i. root mean square speed of the helium atom

ii. kinetic energy of $0.5 mol$ helium atom.

Translational Kinetic energy per particle is

$K_{tr} = \frac{3}{2} k_B T.$

$K_{tr} = \frac{3}{2}(1.38 \times 10^{-23})(298)$

$K_{tr} = 6.16 \times 10^{-21}$ J.

$K_{rot} = 0$ J

K, Kinetic energy per atom $= K_{tr} + \cancel{K_{rot}}^{0} = 6.16(10^{-21})$ J.

For $n = 0.5$ mol,

$E_k = N(K) = 3.01(10^{23})(6.16)(10^{-21})$ J.

(a) A balloon is filled with helium at 25 ^oC. The mass of a helium atom is $6.65 \times 10^{-27}\ kg$. Calculate the

i. root mean square speed of the helium atom

ii. kinetic energy of $0.5 mol$ helium atom.

Total kinetic energy, $E_k = 1854.16\,J$.
for 0.5 mol
He atoms

A sealed cylinder constained 1.2×10^{24} helium atoms at initial pressure $1.04 \times 10^5\ Pa$. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are $315K$ and $1.6 \times 10^3 J$ respectively. The molar mass of helium is $4 gmol^{-1}$ Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas

HOMEWORK!

EXPLAIN BETUL

Thank you!

25th October 2021

A sealed cylinder constained 1.2×10^{24} helium atoms at initial pressure $1.04 \times 10^{5}\ Pa$. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are $315K$ and $1.6 \times 10^{3} J$ respectively. The molar mass of helium is $4 gmol^{-1}$ Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas

missing ①

→ heated

→ T_f tu apa?

→ ΔU tu apa?

missing ⇒ $\Delta N \neq 0$ — ①

Past Year Question

Number of atoms, $N = 1.2 \times 10^{24}$ — i.1

Initial pressure of helium gas, $P_i = 1.04 \times 10^{5}$ Pa — i.2

$T_f = 315K$ — i.3

$\Delta U = 1.6 \times 10^{3}$ J — i.4

symbol mana.

Molar mass of helium gas $= 4\ g\,mol^{-1}$ — i.5

— ki

— condition

a) Based on the equipartition principle, for every degree of freedom, internal energy $(U = \frac{1}{2} kT)$

eqn.

Since the helium is monoatomic, which only have translational motion, degree of freedom, $f = 3$

Number of molecules, $N = 1.2 \times 10^{24}$

therefore, the internal energy, $U = \frac{1}{2} fNkT$ — general eqn.

where k = Boltzmann constant $= 1.38 \times 10^{-23}\ JK^{-1}$

T = temperature

Change in internal energy, $\Delta U = \frac{1}{2} f Nk (\Delta T)$

$$\Delta T = \frac{2(\Delta U)}{fNk}$$

$$\Delta T = \frac{2(1.6 \times 10^{3})}{(3)(1.38 \times 10^{-23})(1.2 \times 10^{24})}$$

$$\Delta T = 64.41 K$$

→ $T_f = T_i + \Delta T$

Initial temperature, $T_i = 315 - 64.41 = 250.59 K$

By using the ideal gas law,

$V = \frac{NkT_i}{P_i}$, (k = Boltzmann constant $= 1.38 \times 10^{-23}\ J K^{-1}$)

+ $\Delta N = 0$

+ number of particles does not change

$\Delta U (\Delta T)$

A sealed cylinder constained 1.2×10^{24} helium atoms at initial pressure 1.04×10^5 Pa. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are $315K$ and $1.6 \times 10^3 J$ respectively. The molar mass of helium is $4 gmol^{-1}$ Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas

$$v = \frac{(1.2 \times 10^{24})(1.38 \times 10^{-23})(250.59)}{1.04 \times 10^5}$$

$v = 0.04 \ m^3$

$\rightarrow V_i = V_f$

\# of moles of Helium gas, $n = \frac{N}{N_A}$, N_A = Avogadro constant $= 6.02 \times 10^{23}$

$$n = \frac{1.2 \times 10^{24}}{6.02 \times 10^{23}}$$

$n = 1.99$ mol

mass of Helium gas, $m = nM$, Molar mass of He $= 4 \ g \ mol^{-1}$ $= (4 \times 10^{-3}) kg \ mo$

$= (1.99)(4 \times 10^{-3})$

$= 7.96 \times 10^{-3}$ kg

Concepts missing

heated $\Rightarrow T_f = T_i + \Delta T$

$\Delta N = 0$

Density of helium gas, $D_{He} = \frac{7.96 \times 10^{-3}}{0.04}$

$= 0.199 \ kg \ m^{-3}$

A sealed cylinder constained 1.2×10^{24} helium atoms at initial pressure 1.04×10^5 Pa. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are $315K$ and $1.6 \times 10^3 J$ respectively. The molar mass of helium is $4gmol^{-1}$ Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas

$$p\boxed{V} = nRT \Rightarrow p = \left(\frac{nR}{V}\right)T \Rightarrow p \propto T$$

$\Delta V = 0$

missing

ideal gas equation

labelling

b) [The pressure of helium gas is directly proportional to the temperature of gas He, at constant volume.]

$$p \boxed{\infty} t$$

label $\frac{P}{t} = k$ constant

therefore, $\frac{P_i}{T_i} = \frac{P_f}{T_f}$

P initial

P final

where $P_i = 1.04 \times 10^5$ Pa

$P_f = x$

$T_i = 250.59$ K

$t_f = 315$ k

$$\frac{P_i}{t_i} = \frac{P_f}{T_f}$$

$$\frac{(1.04 \times 10^5)}{250.59\text{ k}} = \frac{x}{315\text{ k}}$$

$x = 130731.\cancel{47}$ Pa

$\therefore P_f = 130731.\cancel{47}$ Pa

A sealed cylinder constained 1.2×10^{24} helium atoms at initial pressure $1.04 \times 10^5\ Pa$. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are $315K$ and $1.6 \times 10^3 J$ respectively. The molar mass of helium is $4gmol^{-1}$ Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas

a) density

no labels

$N = 1.2 \times 10^{24}$

$P_2 = 1.04 \times 10^5\ Pa$

$T_F = 315\ K$

$\Delta U = 1.6 \times 10^3 J$

$M = 4\ g\ mol^{-1}$

$R = 8.31$ $\boxed{\text{unit}}$

$T = 315k$

$V_{rms}\ (T)$ is given by,

$$\boxed{V_{rms}} = \sqrt{\frac{3RT}{M}}$$

mana dapat?

$$= \sqrt{\frac{(3)(8.31)(315)}{0.004}}$$

$p(\rho)$

$$\boxed{p} = 1/3 \rho (V_{rms})^2$$

$$1.04 \times 10^5 = 1/3 \rho (1401.15)^2$$

$$\rho = 0.16\ kgm^{-3}$$

label

b) $pV = 1/3\ Nm(V_{rms})^2$

$$n_{He} = \frac{1.2 \times 10^{24}}{6.02 \times 10^{23}}$$

$\Delta U = 3/2\ Nk\ \Delta T$

$1.6 \times 10^3 = 3/2\ (1.2 \times 10^{24})(1.38 \times 10^{-23})(315 - T_i)$

$T_i = 250.59k$

(Since V is constant) KE condition

$= (PV = nRT)$ initial

$(1.04 \times 10^5)(V) = 1.99(8.31)(250.59)$

$V = 0.04 m^3$

$= PV = nRT)$ final

$P_{final}\ (0.04) = 1.99(8.31)(315)$

$P_{final} = 1.30 \times 10^5\ Pa$

???

A sealed cylinder constained 1.2×10^{24} helium atoms at initial pressure 1.04×10^5 Pa. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are $315K$ and $1.6 \times 10^3 J$ respectively. The molar mass of helium is $4 g mol^{-1}$ Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas

missing

List of info given.

a) Number of mol, $n = \frac{N}{N_A} = \frac{1.2 \times 10^{24}}{6.02 \times 10^{23}}$

label

$= 1.99$ mol

what is this

Change in internal energy, $\Delta U = n\left(\frac{f}{2}R\right)\Delta T$, where the degree of freedom, $f = 3$ for helium (monatomic gas)

Rearrange

$\Delta T = \frac{2}{3}\frac{\Delta U}{nR} = \frac{2}{3} \times \frac{1.6 \times 10^3}{1.99 \times 8.31}$

$= 64.5K$

condition

Final temperature, $T_2 = T_1 + \Delta T$

$T_1 = T_2 - \Delta T$

$= 315 - 64.5K$

$= 250.5K$

Using the ideal gas equation,

label

$pV = nRT$

$V = \frac{nRT}{p}$

$= \frac{1.99 \times 8.31 \times 250.5}{1.04 \times 10^5}$

$= 3.983 \times 10^{-2} m^3$

$= 0.200 kg\, m^{-3}$

b) Using (Pressure law) (at constant volume),

$\frac{P_2}{T_2} = \frac{P_1}{T_1}$

label,

where did this come from?

$P_2 = P_1 \frac{T_2}{T_1}$

$= \frac{1.04 \times 10^5 \times 315}{250.5}$

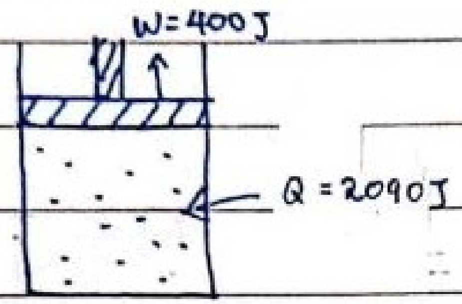
$= 1.31 \times 10^5 Pa$

Thank you!

27th October 2021

1. A system absorbs 2090 J of heat and the same time does 400 J of work.

1.



$\Delta U = \Delta Q - \Delta W$

$-$

Based on (First law of thermodynamic),

$\Delta Q = \Delta U + \Delta W$

where Q = absorbed heat energy = 2090 J

W = Work done by the gas = 400 J

ΔU = Change in internal energy.

$\therefore \Delta U = Q - W$

$= 2090 - 400$

$= 1690\ J = 1.69\ kJ$

3. 5020 J of heat is removed from a gas held at constant volume.

3. 5020 J of heat is removed from a gas held at constant volume.

Q = heat is removed = -5020 J

At constant volume, $\Delta V = 0$

$W = \int p\,dV$

$\Delta W = 0$

$\Delta U = \Delta Q$

$= -5020$ J

Based on the first law of Thermodynamics

$(\Delta U = Q + W)$

heat absorbed

work done onto system

Compute the internal energy change and temperature change for the two processes involving 1 mole of an ideal monatomic gas.

(a) 1500 J of heat are added to the gas and the gas does $\boxed{\text{no}}$ work and $\boxed{\text{no}}$ work is done on the gas

(b) 1500 J of work are done on the gas and the gas does no work and no heat is added or taken away from the gas

ideal : $pV = nRT = Nk_BT$

monoatomic : DOF = 3.

gas

$U = \frac{f}{2} Nk_BT = \frac{f}{2} nRT$

a b

$\Delta U = \frac{f}{2} nR\Delta T$

Chapter 13.

ΔQ, ΔW : Chapter 14

$\Delta U = \Delta Q + \Delta W$

energy absorbed

work done onto the system

a $\Delta W = 0$

$\Delta U = \Delta Q = 1500J.$

$\frac{3}{2}(1)(8.31)\Delta T = 1500J$

$\Delta T \approx 120K$

b $\Delta U = \Delta Q + \Delta W$

heat absorbed

onto.

$\Delta Q = 0$

$\Delta U = \Delta W = 1500J.$

$\frac{f}{2} nR\Delta T = 1500J.$

$\frac{3}{2}(1)(8.31)\Delta T = 1500J$

$\Delta T \approx 120K.$

Thank you!

26th October 2021

Thermodynamics

Time allocation:
1.5h (Lecture) + 3h (Tutorial)
Learning Outcomes:

1. State the first law of thermodynamics.
2. Solve problem related to first law of thermodynamics.
3. Define the following thermodynamics processes:
   - Isothermal
   - Isochoric
   - Isobaric
   - Adiabatic
4. Discuss p-V graph for all the thermodynamic processes.
5. Discuss work done in isothermal, isochoric and isobaric processes.
6. Solve problem related to work done in
   - isothermal process, $W = nRT\ ln\,\frac{V_2}{V_1} = nRT\ ln\,\frac{p_1}{p_2}$;
   - isobaric process, $W = \int p\,dV = p\,(V_2 - V_1)$;
   - isochoric process, $W = \int p\,dV = 0$.

$\Delta U(\Delta Q, \Delta W)$

into / out of

by / onto.

Consider $\Delta W = 0$

$\Delta U(\Delta Q) \Rightarrow$ define ΔQ = heat into system

$\uparrow \Delta Q \Rightarrow \uparrow \Delta U$

Consider $\Delta Q = 0$

$\Delta U(\Delta W) \Rightarrow$ define ΔW = work done by the system

Time allocation:
1.5h (Lecture) + 3h (Tutorial)
Learning Outcomes:

1. State the first law of thermodynamics.
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   - isochoric process, $W = \int p\,dV = 0$.

Consider $\Delta Q = 0$

$\Delta U(\Delta W) \Rightarrow$ define ΔW = work done by the system

$\Delta U = -\Delta W$

Counter argument

define ΔW = work done onto the system

$\Delta U = +\Delta W$

$\Delta U = \Delta Q + \Delta W \leftarrow$ onto.

$\Delta U = \Delta Q - \Delta W \leftarrow$ by.

Time allocation:
1.5h (Lecture) + 3h (Tutorial)
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   - isochoric process, $W = \int p\, dV = 0$.

$\boxed{\Delta U} = \Delta Q + \Delta W$ onto.

$\downarrow$ rearrange

$\boxed{\Delta Q} = \boxed{\Delta U} - \Delta W$ onto

change heat — total change — change to work onto

10 candles → 5 goes to Eamonn
→ x goes to Fernado

Fernado dapat berapa?

$F = ma \rightarrow \frac{F}{m} = a$

Time allocation:
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3. Define the following thermodynamics processes:
   - Isothermal
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   - Adiabatic

   case studies
4. Discuss p-V graph for all the thermodynamic processes.
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   - isochoric process, $W = \int p\, dV = 0$.

~~The~~ TD processes

$\Delta U = \Delta Q \pm \Delta W$

$pV = nRT$
(ideal gas equation)

$Q = mc\theta$ | $\Delta W = p\,\Delta V$ (p: pressure; ΔV: volume)
$Q = mL$

1 Case 1

Isothermal
same → same $T \Rightarrow \Delta U = 0 \Rightarrow \boxed{\Delta Q = \pm \Delta W}$

2 Case 2

Isochoric / Isovolumetric
volume same

$\Delta W = p\,\Delta V \Rightarrow \Delta W = 0 \Rightarrow \boxed{\Delta Q = \Delta U}$ (ΔV ↓ 0)

Time allocation:
1.5h (Lecture) + 3h (Tutorial)
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   - isobaric process, $W = \int p\, dV = p\,(V_2 - V_1)$;
   - isochoric process, $W = \int p\, dV = 0$.

3 Case 3

Isobaric

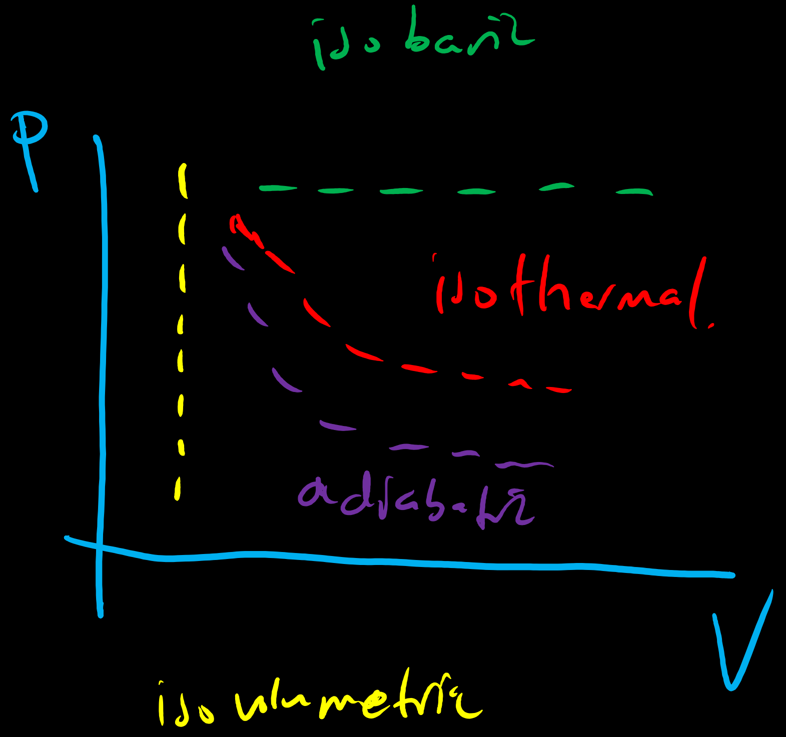
→ same pressure

→ $\Delta Q \neq 0$

→ $\Delta W \neq 0$

$\Downarrow$

$\Delta U = \Delta Q \pm \Delta W$



4 Case 4

Adiabatic → no change in heat transfer

$\Delta Q = 0$

$\Downarrow$

$\Delta U = \pm \Delta W$

Time allocation:
1.5h (Lecture) + 3h (Tutorial)
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   - isochoric process, $W = \int p\,dV = 0$.

Work done equations

Case 1: isothermal ($\Delta T = 0$)

$dW = p\,dV$

$\int dW = \int p\,dV$

refer to ideal gas eqn : $pV = nRT$

$p = \frac{nRT}{V}$

$W = nRT \int \frac{dV}{V} = nRT \ln\left(\frac{V_2}{V_1}\right)$

$\int x^{-1}\,dx = \ln(x) + c$

Time allocation:
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   - isochoric process, $W = \int p\, dV = 0$.

Case 2: isochoric

$dW = p\,dV$

$dV = 0$

$dW = 0$

Case 3: ~~isobaric~~ isobaric

$dW = p\,dV$

$\Delta p = 0$

$W = \int p\,dV$

$W = p \int dV$ $\rightarrow$ $W = p(V_2 - V_1)$.

constant

Time allocation:
1.5h (Lecture) + 3h (Tutorial)
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2. Solve problem related to first law of thermodynamics.
3. Define the following thermodynamics processes:
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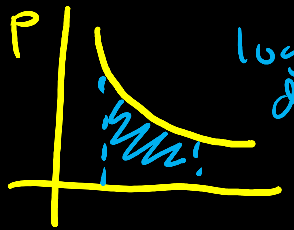
     $W = \int p\,dV = p\,(V_2 - V_1)$;
   - isochoric process,
     $W = \int p\,dV = 0$.

Comparison	iso thermal	baric
idea	$\Delta T = 0$	$\Delta p = 0$
constant	internal energy	pressure
not constant	pressure ① $p(V)$ ② Volume	Volume
eqn	$W = nRT\ln\left(\frac{V_2}{V_1}\right)$	$W = p(V_2 - V_1)$



$W = p(\Delta V)$
rectangle

Time allocation:
1.5h (Lecture) + 3h (Tutorial)
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   - isochoric process, $W = \int p\, dV = 0$.

Refer to

ideal gas ~~equation~~ situation:

$$U = \underbrace{\frac{f}{2}}_{\text{constants}} N k_B T$$

$$\Delta U = \frac{f N k_B}{2} \Delta T$$

$$\Delta U (\Delta T)$$

$$\Delta U \neq \Delta T$$

Time allocation:
1.5h (Lecture) + 3h (Tutorial)
Learning Outcomes:

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   - isobaric process,
     $W = \int p\, dV = p\,(V_2 - V_1)$;
   - isochoric process,
     $W = \int p\, dV = 0$.

Adiabatic

$\Delta Q = 0$ does not mean $\Delta T = 0$

$\Delta U = \pm \Delta W$

equation for ΔW requires heat capacities

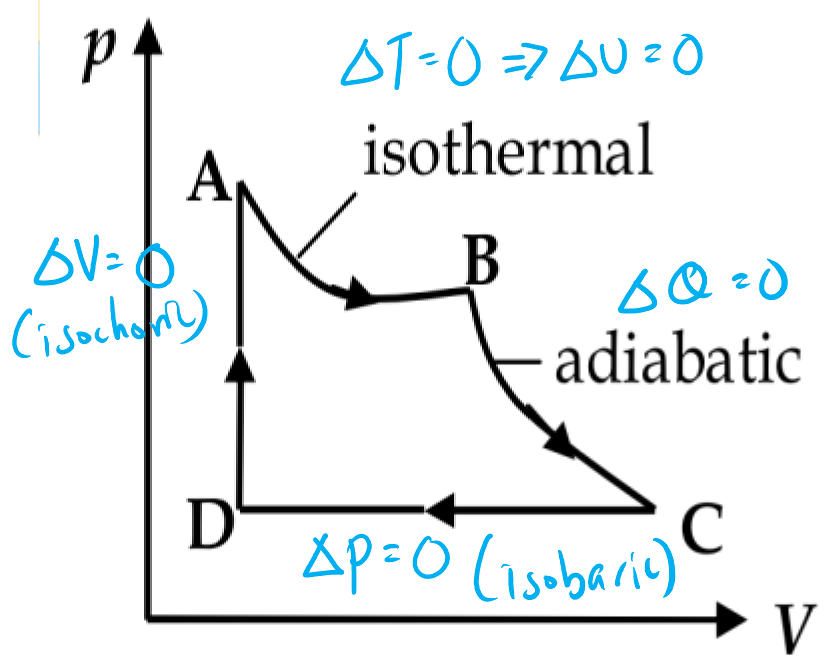
$\Delta (PV^{\gamma}) = 0$

$\gamma = \frac{C_p}{C_v}$ $\Big\}$ $Q = mc\theta$

dependency on the $\boxed{\text{type of gas}}$

Thank you!

29TH October 2021

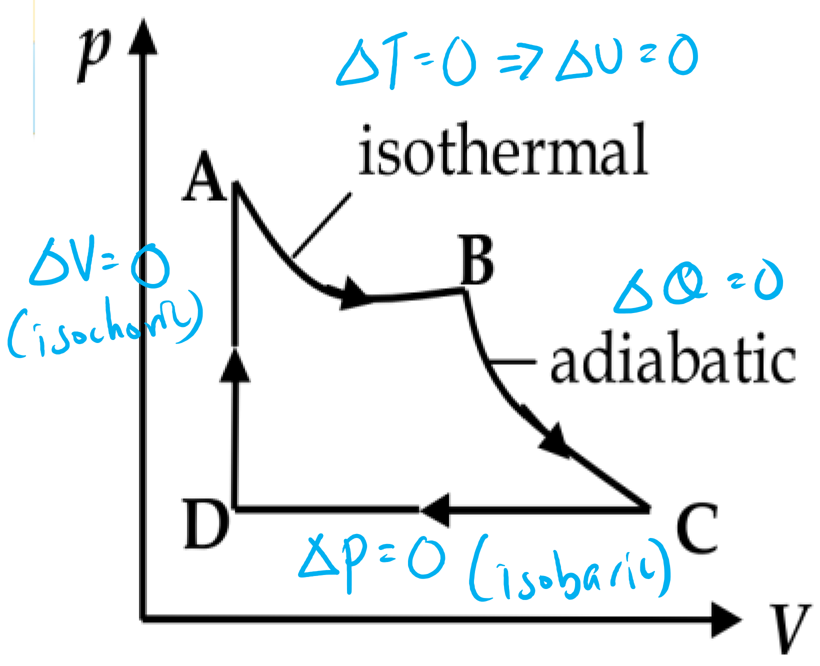


A gas system undergoes thermodynamic changes as shown in the figure.

If Q is the heat transferred, W is the work done and ΔU is the change in internal energy, then complete the table below with signs (+), (−) or 0 for values of Q, W, ΔU which are obtained in the processes AB, BC, CD and DA.

work done onto gas

	Q	W	ΔU
AB	+	−	0
BC	0	−	−
CD	+	+	+
DA	+	0	+

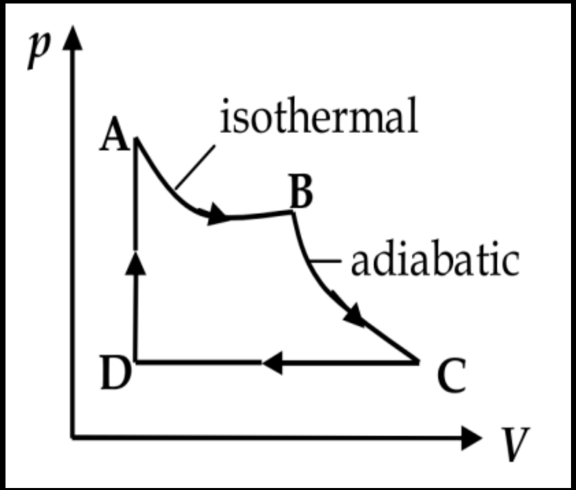


A gas system undergoes thermodynamic changes as shown in the figure.

If Q is the heat transferred, W is the work done and ΔU is the change in internal energy, then complete the table below with signs (+), (–) or 0 for values of Q, W, ΔU which are obtained in the processes AB, BC, CD and DA.

work done by gas

	Q	W	ΔU
AB	+	+	0
BC	0	+	–
CD	+	–	+
DA	+	0	+



	Q	W	ΔU
AB			
BC			
CD			
DA			

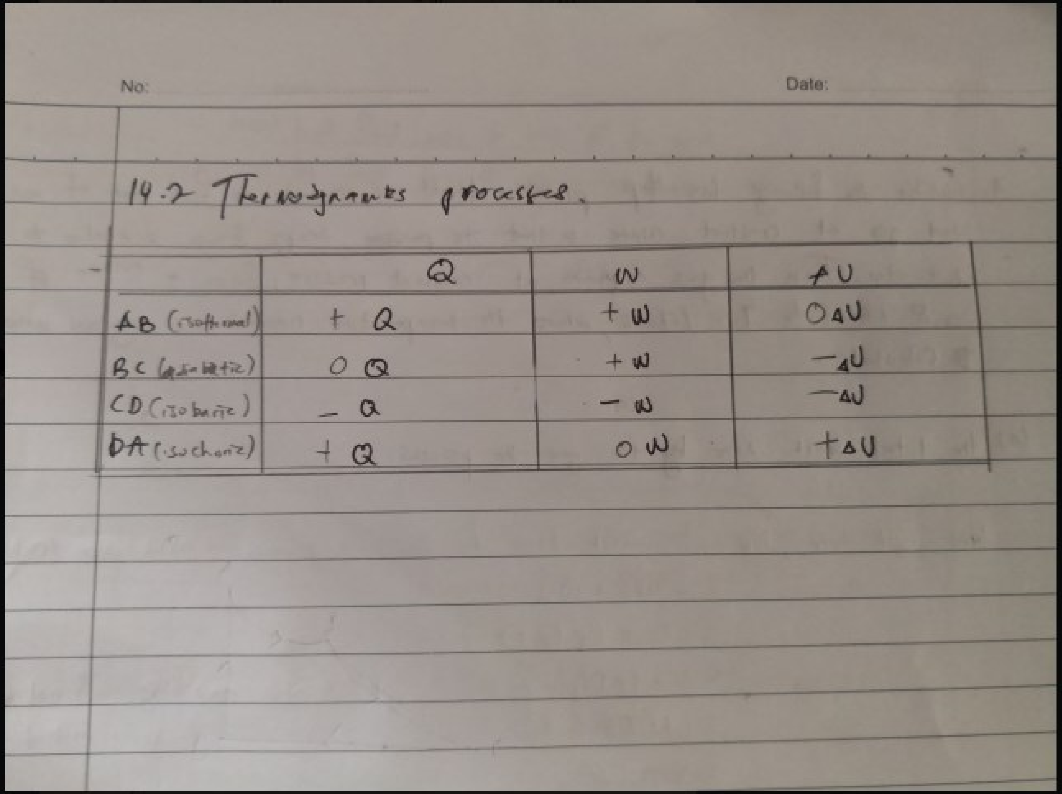
$+Q$: heat into system

$-Q$: heat out of system

$+W$: work done onto system

$-W$: work done by system

$$\Delta U = Q + W$$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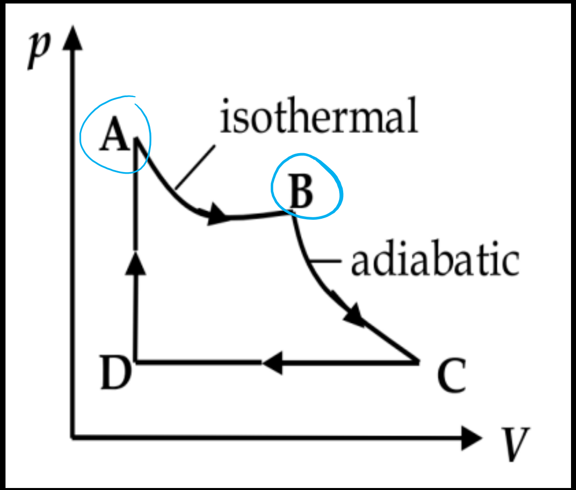
14.2 Thermodynamics processes.

	Q	W	ΔU
AB (isothermal)	+ Q	+ W	0 ΔU
BC (adiabatic)	0 Q	+ W	$-\Delta U$
CD (isobaric)	− Q	− W	$-\Delta U$
DA (isochoric)	+ Q	0 W	$+\Delta U$



	Q	W	ΔU
AB	+	~~t~~ -	0
BC			
CD			
DA			

AB: $\Delta T = 0$, $\Delta U = 0$

$\cancel{\Delta U}^{0} = Q + W$

$Q = -\underbrace{W}$

heat in

work by gas

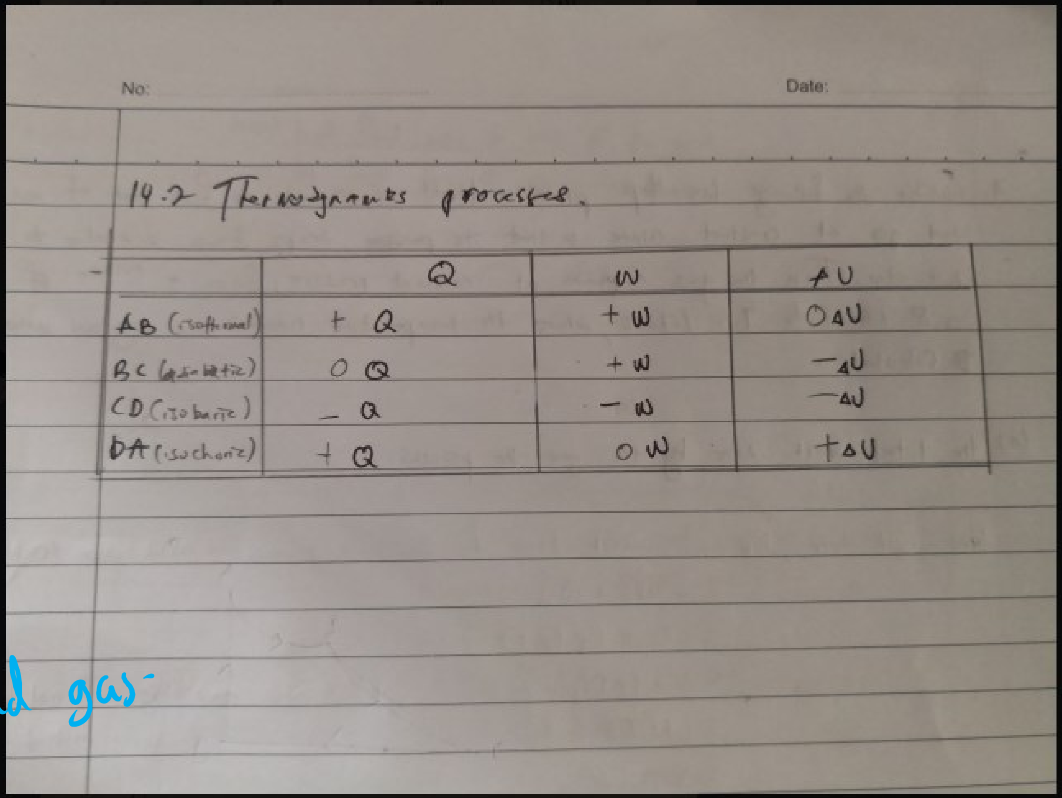
W ← work done onto gas

$V_B > V_A$

$W > 0$

$V_B - V_A > 0$

work done by the system to expand gas.

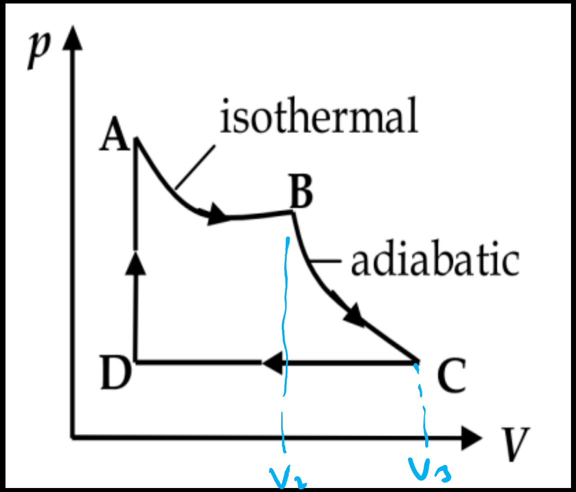


No:

Date:

14.2 Thermodynamics processes.

	Q	W	ΔU
AB (isothermal)	+ Q	+ W	0 ΔU
BC (adiabatic)	0 Q	+ W	− ΔU
CD (isobaric)	− Q	− W	− ΔU
DA (isochoric)	+ Q	0 W	+ ΔU



	Q	W	ΔU
AB			
BC	0	−	−
CD			
DA			

$$BC:\ \Delta U = \cancel{Q}^{0} + W$$

$$\Delta U = W$$

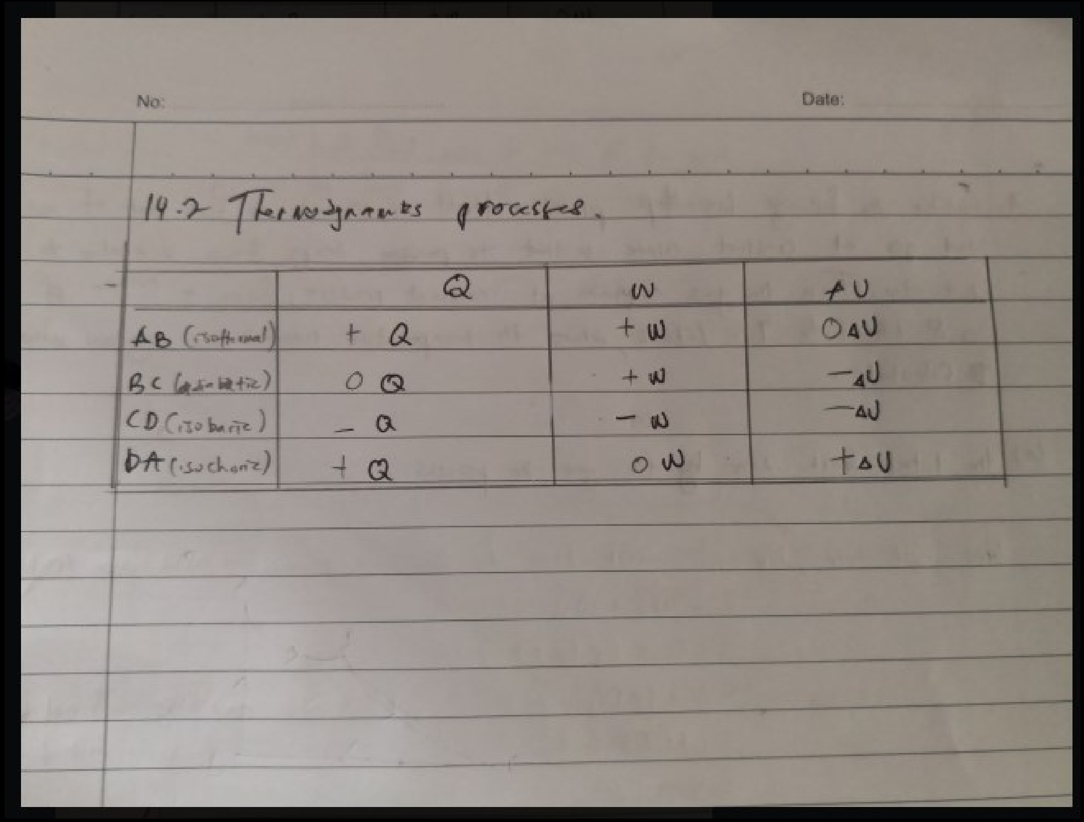
$$V_3 > V_2$$

$$V_3 - V_2 > 0$$

$$W > 0$$

work done by gas

so internal energy lessen.



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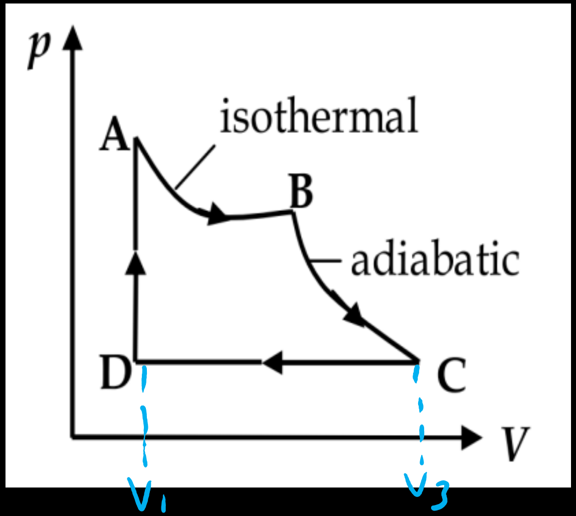
Date:

14.2 Thermodynamics processes.

	Q	W	ΔU
AB (isothermal)	+ Q	+ W	0 ΔU
BC (adiabatic)	0 Q	+ W	− ΔU
CD (isobaric)	− Q	− W	− ΔU
DA (isochoric)	+ Q	0 W	+ ΔU



	Q	W	ΔU
AB			
BC			
CD	+	+	+
DA			

CD: $\Delta p = 0$; $\Delta U = Q + W$

$W = \Delta U - Q$

$V_1 = V_f$ $V_i = V_3$.

$V_3 > V_1$

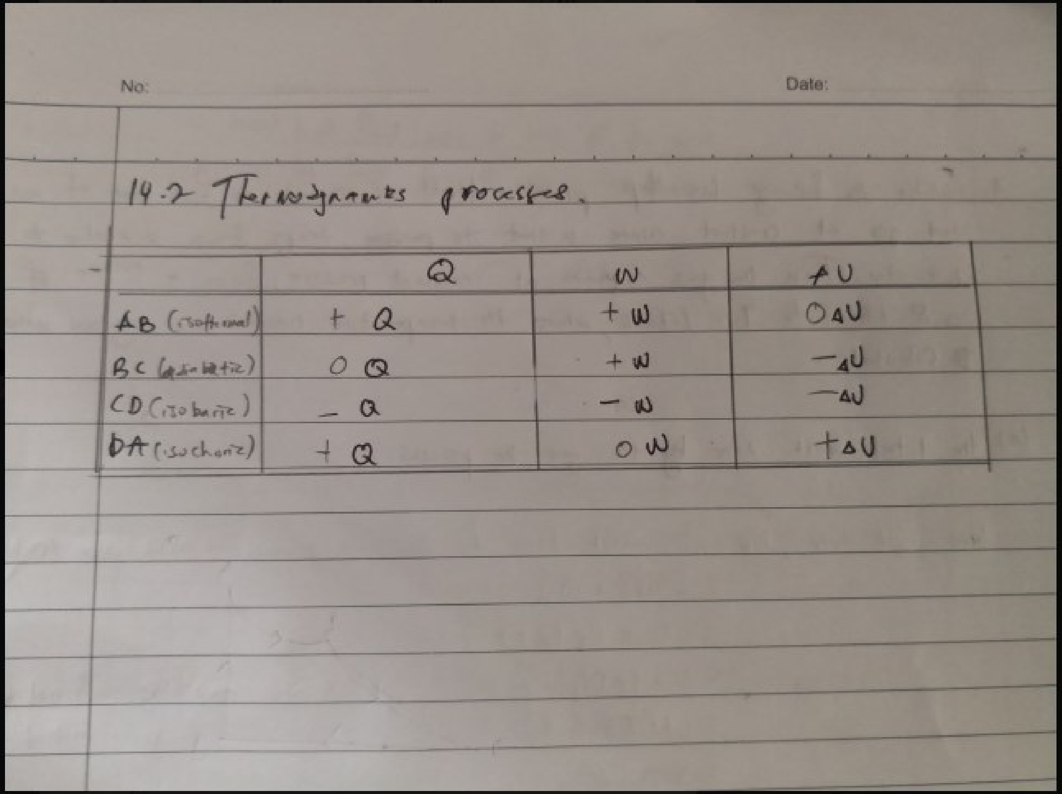
$V_f < V_i$

$V_f - V_i < 0$

$W < 0$

$\Delta U - Q < 0$

$\Delta U < Q$



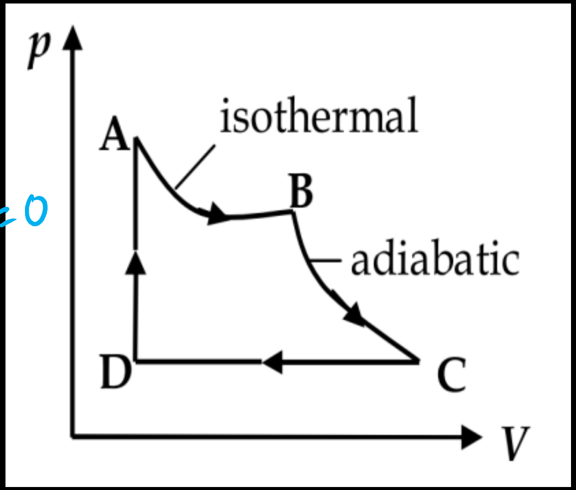
No:

Date:

14.2 Thermodynamics processes.

	Q	W	ΔU
AB (isothermal)	+ Q	+ W	0 ΔU
BC (adiabatic)	0 Q	+ W	− ΔU
CD (isobaric)	− Q	− W	− ΔU
DA (isochoric)	+ Q	0 W	+ ΔU

$\Delta V = 0$



	Q	W	ΔU
AB			
BC			
CD			
DA	+	0	+

$$DA: \Delta U = Q + \cancel{W}^{\,0}$$

$$\Delta U = Q.$$

No: Date:

14.2 Thermodynamics processes.

	Q	W	ΔU
AB (isothermal)	+ Q	+ W	0 ΔU
BC (adiabatic)	0 Q	+ W	− ΔU
CD (isobaric)	− Q	− W	− ΔU
DA (isochoric)	+ Q	0 W	+ ΔU

1. A gas expands under constant temperature condition and does work of $30J$ against the surrounding.

   a) What is the change in the internal energy of the gas?

   b) Find the amount of heat absorbed or lost by the gas.

$\cancel{\Delta U}^{\,0} = \Delta Q \pm \Delta W$

$\boxed{\Delta U = \frac{1}{2} k \Delta T}$ equipartition theorem

14.3

apa definition

1. $\boxed{\Delta W = 30J}$

$\Delta U = \Delta Q - \Delta W$

$\cancel{\Delta Q}$ $\Delta U = 0$

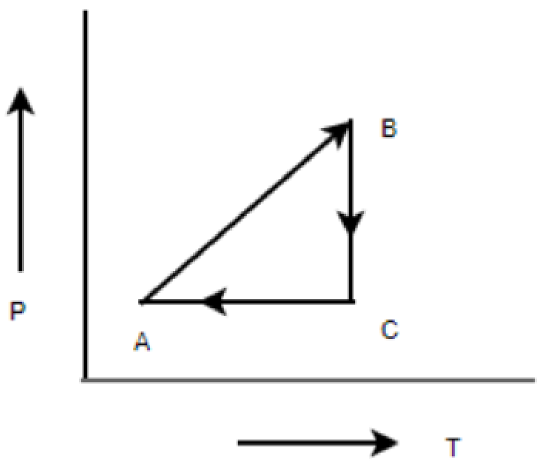
$\boxed{\text{Constant temperature, } \Delta U = 0}$ so $Q = W$

a) $\boxed{0J}$ $(\Delta U(\Delta T), \Delta T = 0, \Delta U = 0)$

b) $Q = W$

$Q = 30J$

A cyclic Process is shown in the given below p-T digram.



Sketch its equivalent p-V diagram.

Homework!!

Carnot's Engine

TD process

expansion/compression

cyclic

Thank you!

1st November 2021

2 (a) A car is moving with constant speed of 80 km h^{-1} when suddenly the driver sees a cat 50 m straight ahead of the car. The driver's reaction time is 0.5 s and the maximum deceleration of the car is 10 m s^{-2}.

Sebuah kereta bergerak dengan kelajuan malar 80 km j^{-1} *apabila tiba-tiba pemandu melihat seekor kucing* 50 m *di hadapan kereta. Masa reaksi pemandu ialah* 0.5 s *dan nyahpecutan maksimum kereta ialah* 10 m s^{-2}.

(i) Calculate the total distance travelled by the car from the moment the driver sees the cat until it stopped. What happens to the cat?

Hitung jumlah jarak yang dilalui oleh kereta dari saat pemandu melihat kucing hingga kereta berhenti. Apa yang terjadi kepada kucing tersebut?

(ii) Sketch acceleration against time graph to show the motion of the car.

Lakarkan satu graf pecutan melawan masa yang menunjukkan gerakan kereta.

[7 *marks*]
[7 *markah*]

2 (a) A car is moving with constant speed of 80 km h^{-1} when suddenly the driver sees a cat 50 m straight ahead of the car. The driver's reaction time is 0.5 s and the maximum deceleration of the car is 10 m s^{-2}.

Sebuah kereta bergerak dengan kelajuan malar 80 km j^{-1} apabila tiba-tiba pemandu melihat seekor kucing 50 m di hadapan kereta. Masa reaksi pemandu ialah 0.5 s dan nyahpecutan maksimum kereta ialah 10 m s^{-2}.

(i) Calculate the total distance travelled by the car from the moment the driver sees the cat until it stopped. What happens to the cat?

Hitung jumlah jarak yang dilalui oleh kereta dari saat pemandu melihat kucing hingga kereta berhenti. Apa yang terjadi kepada kucing tersebut?

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Lakarkan satu graf pecutan melawan masa yang menunjukkan gerakan kereta.

[7 *marks*]
[7 *markah*]

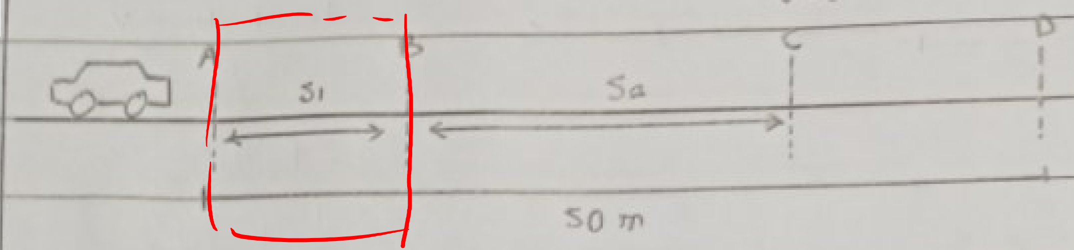
PSPM 18/19

$80 \frac{\boxed{km}}{\boxed{h}} \times \frac{1000\ m}{1\ km} \times \frac{1\ h}{3600\ s} = 22.22\ \boxed{m/s}$ (constant speed) ✓1

$u = 22.22\ m/s$ $t_1 = 0.5\ s$

$s = 50\ m$, $a = -10\ m/s^2$

$v = 0$



reaction

from A to B : using $s = ut$

$s_1 = 22.22\ m/s \times 0.5\ s$ ✓G1

$= 11.11\ m$

deceleration phase

from (B to C) : using $v^2 = u^2 + 2as$

$0 = (22.22)^2 + 2(-10)(s_2)$ ✓G1

$20 s_2 = 22.22^2$

$s_2 = 24.69$ ~~m~~

3,

2 (a) A car is moving with constant speed of 80 km h^{-1} when suddenly the driver sees a cat 50 m straight ahead of the car. The driver's reaction time is 0.5 s and the maximum deceleration of the car is 10 m s^{-2}.

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5

Hitung jumlah jarak yang dilalui oleh kereta dari saat pemandu melihat kucing hingga kereta berhenti. Apa yang terjadi kepada kucing tersebut?

(ii) Sketch acceleration against time graph to show the motion of the car.

2

Lakarkan satu graf pecutan melawan masa yang menunjukkan gerakan kereta.

[7 *marks*]
[7 *markah*]

Total distance travelled $= S_1 + S_2$

$= 11.11 + 24.69$ m

$= 35.80$ m

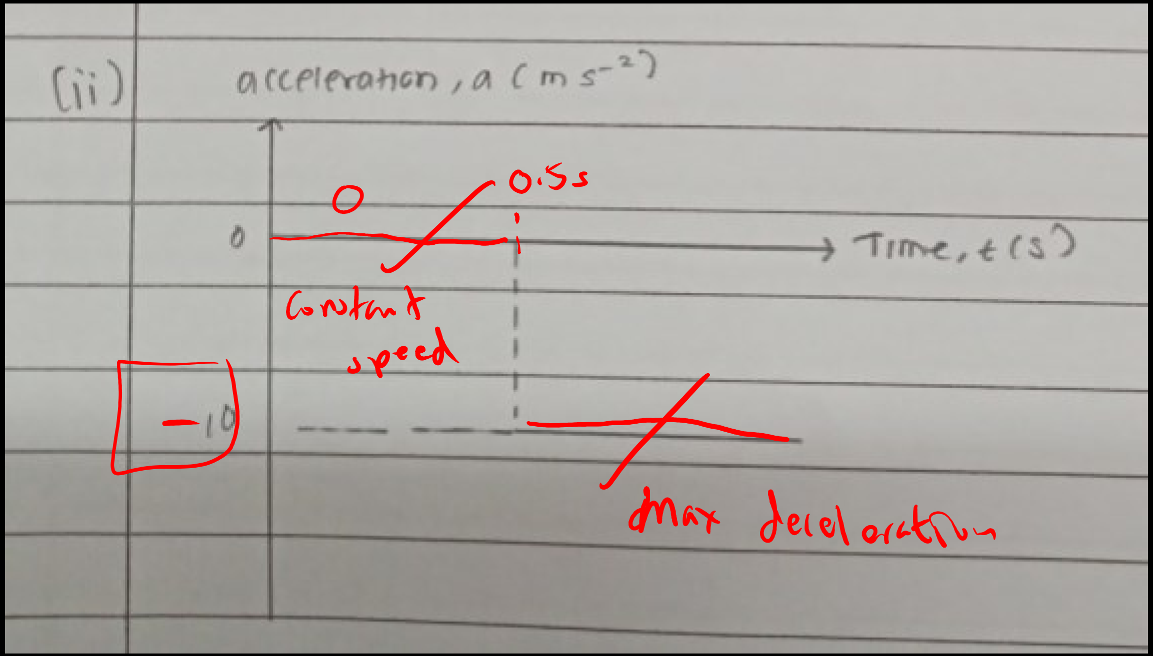
JUJ

Distance of C from D $= 50 - 35.80 = 14.20$ m

therefore, the car is stopped 14.20 m in front of the cart.

JUJ

5



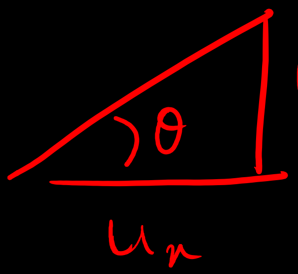
-1

(b) A man runs off a horizontal diving board with a speed of 2.5 m s^{-1} and falls into the swimming pool at a horizontal distance of 5.0 m from the end of the board. Determine the height of the diving board above the water surface.

Seorang lelaki berlari dari papan anjal mengufuk dengan laju ... jatuh dalam kolam renang pada jarak ufuk 5.0 m dari hujung p... Tentukan tinggi papan anjal dari permukaan air.

x-axis : $\boxed{\boxed{S_x} = u_x t}$

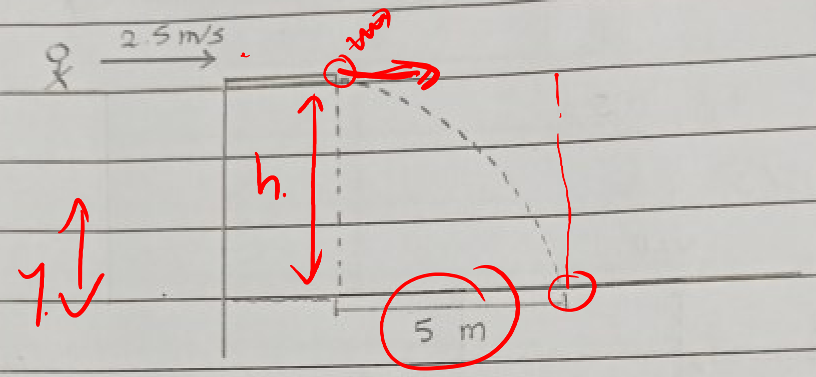
y-axis : $\boxed{S_y} = u_y t - \frac{1}{2} g t^2$



u_y X

$\rightarrow u_x$ ✓

b)



for horizontal motion : $s = u_x t$

$t = \frac{s}{u_x}$

$t = \frac{5.0}{2.5}$ s G1

$\boxed{\boxed{t} = 2.0 \text{ s}}$

downward, +.

for vertical motion : $s = ut + \frac{1}{2} at^2$, where $a = \boxed{+}g = \boxed{+}9.81$ ms^{-2} G1

$h = 0 + \frac{1}{2}(9.81)(2.0)^2$ ✓

$= 19.62$ m J4

Chapter 3: Dell's solution

3 A fisherman on a stationary boat jumps off onto a jetty with a velocity of $\boxed{1.5 \text{ m s}^{-1}}$, causing the boat to move backwards.

Seorang nelayan dalam sebuah bot pegun melompat ke jeti dengan halaju 1.5 m s^{-1}, *menyebabkan bot terundur ke belakang.*

(a) If the mass of the fisherman and boat are 60 kg and 450 kg, (determine the velocity of the boat.)

Jika jisim nelayan dan bot ialah 60 kg *dan* 450 kg, *tentukan halaju bot.*

$\Delta p = 0$

[3 *marks*]
[3 *markah*]

contact time

(b) If the fisherman's feet are in contact with the jetty for $\boxed{10 \text{ ms}}$, determine the magnitude of the average force exerted on his feet.

Jika kaki nelayan bersentuhan dengan jeti selama 10 ms, *tentukan magnitud daya purata yang dikenakan pada kakinya.*

$F = \frac{\Delta p}{\Delta t}$ ← change in momentum

contact time

[3 *marks*]
[3 *markah*]

3 A fisherman on a stationary boat jumps off onto a jetty with a velocity of 1.5 m s^{-1}, causing the boat to move backwards.

Seorang nelayan dalam sebuah bot pegun melompat ke jeti dengan halaju 1.5 m s^{-1}, *menyebabkan bot terundur ke belakang.*

(a) If the mass of the fisherman and boat are 60 kg and 450 kg, determine the velocity of the boat.

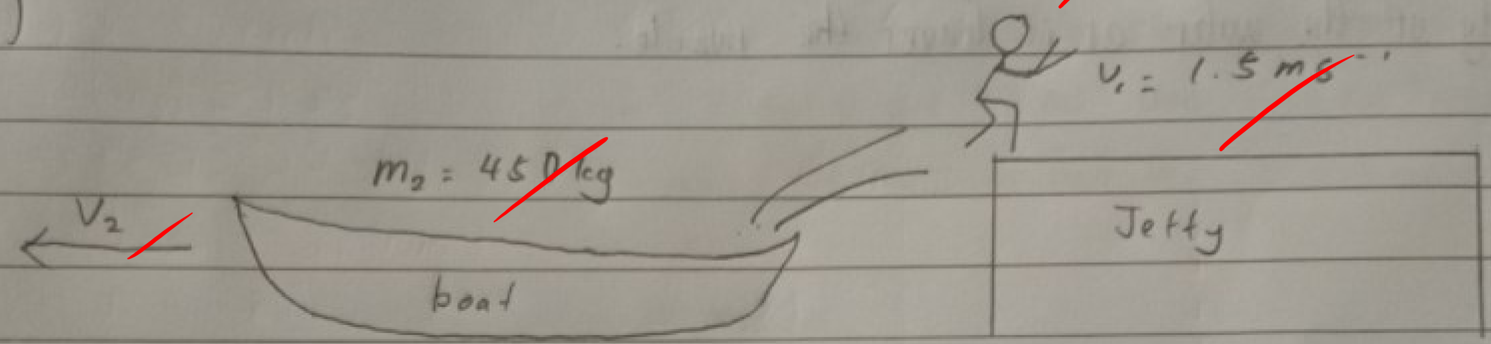
Jika jisim nelayan dan bot ialah 60 kg *dan* 450 kg, *tentukan halaj*

(b) If the fisherman's feet are in contact with the jetty for 10 ms, deter magnitude of the average force exerted on his feet.

Jika kaki nelayan bersentuhan dengan jeti selama 10 ms, *tentukan daya purata yang dikenakan pada kakinya.*

(b) If the fishermen's feet in contact with the jetty for 10 ms, determine the magnitude of the average force exerted on his feet.

(a)



By the principle of conservation of linear momentum,

Total final momentum = Total initial momentum ✓ K1

$m_1 V_1 = -m_2 V_2$

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2)(0)$$

stationary

$$v_2 = -\frac{m_1 v_1}{m_2}$$

$$= -\frac{60 \times 1.5}{450}$$ ✓ G1

$$= -0.2 \text{ ms}^{-1}$$ ✓ Jul

3 A fisherman on a stationary boat jumps off onto a jetty with a velocity of 1.5 m s^{-1}, causing the boat to move backwards.

Seorang nelayan dalam sebuah bot pegun melompat ke jeti dengan halaju 1.5 m s^{-1}, *menyebabkan bot terundur ke belakang.*

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Jika jisim nelayan dan bot ialah 60 kg *dan* 450 kg, *tentukan halaju bot.*

[3 *marks*]
[3 *markah*]

(b) If the fisherman's feet are in contact with the jetty for 10 ms, determine the magnitude of the average force exerted on his feet.

Jika kaki nelayan bersentuhan dengan jeti selama 10 ms, *tentukan magnitud daya purata yang dikenakan pada kakinya.*

[3 *marks*]
[3 *markah*]

Definition

(b) Impulse = Change of linear momentum of the fisherman

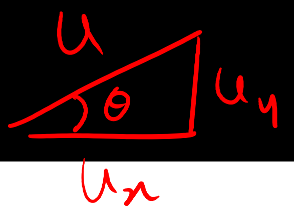
$Ft = m_1(v-u)$

$F = \dfrac{m_1(v-u)}{t}$

$F = \dfrac{60(0-1.5)}{0.01}$

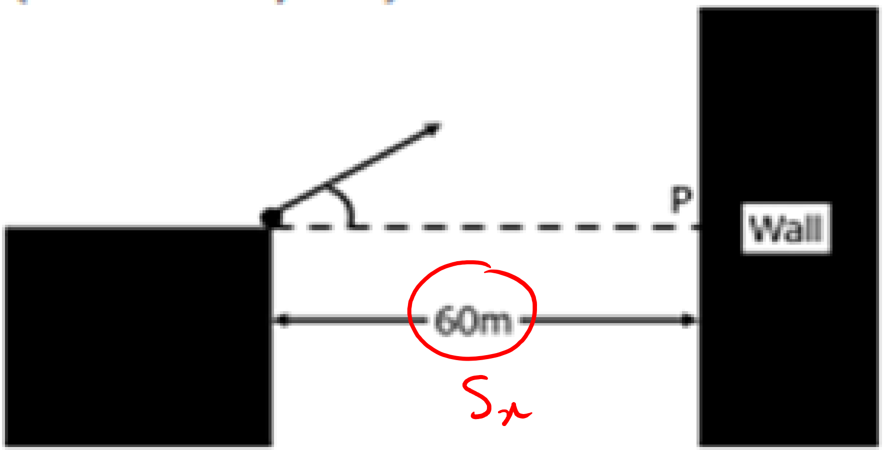
$F = 9000\ \text{N}$ or ~~9.0k N~~ JUL

$$|\vec{F}| = \frac{m|\Delta\vec{v}|}{t}$$



$u_x = u\cos\theta$

8. **(PSPM 11/12)**



$S_x = u_x t$

$t = \frac{S_x}{u_x} = \frac{60}{20\cos 40} = 3.92 \text{ s}$

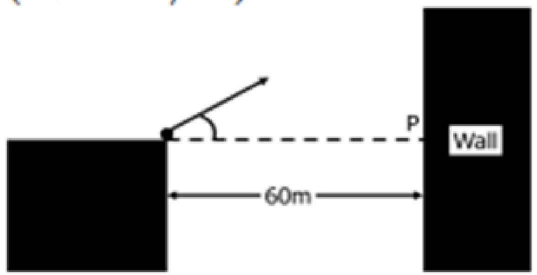
The figure above shows a balls being thrown from the top of a building towards a wall 60m away. The initial velocity is 20ms^{-1} at 40^o to the horizontal.

(a) How much time does it take to hit the wall?

(b) What is the distance between P and the position the ball strike the wall?

(c) What is the speed of the ball when it strikes the wall?

8. **(PSPM 11/12)**



The figure above shows a balls being thrown from the top of a building towards a wall $60m$ away. The initial velocity is $20ms^{-1}$ at 40^o to the horizontal.

(a) How much time does it take to hit the wall?

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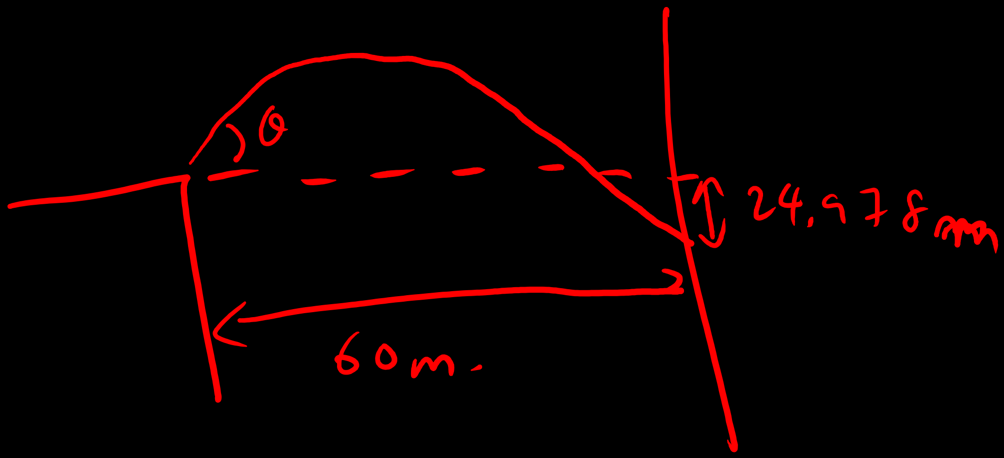
(c) What is the speed of the ball when it strikes the wall?



projectile path

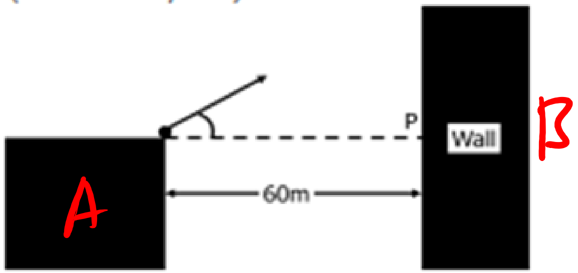
$t = 3.92\,s$

$S_y = (u \sin\theta)t - \frac{1}{2}gt^2$

$= 20 \sin 40 (3.92) - \frac{1}{2}(9.81)(3.92)^2$

$S_y \approx -24.978\,m$

8. (PSPM 11/12)



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(a) How much time does it take to hit the wall?

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(c) What is the speed of the ball when it strikes the wall?

$S_i = u_i t + \frac{1}{2} a_i t^2$

$V_i = u_i + a_i t$

3.92 s to travel from A to B.

$V_x = u_x + \cancel{a_x t} \rightarrow 0$

$V_x = u_x$

$V_x = u \cos \theta$

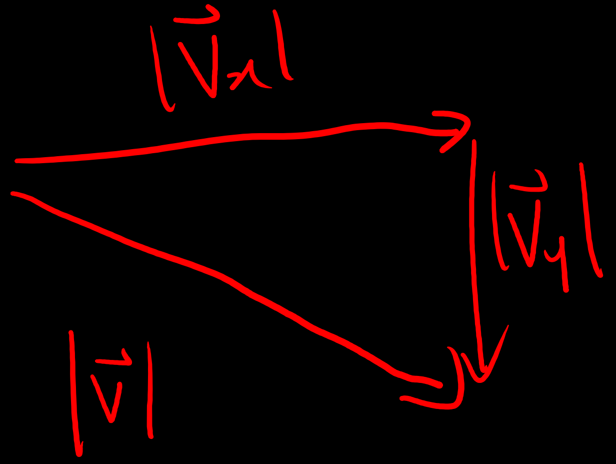
$V_x \approx 20 \cos 40$

$\boxed{V_x \approx 15.321\ ms^{-1}}$

$V_y = u_y + a_y t$

$V_y = 20 \sin 40 - 9.81 (3.92)$

$V_y \approx -25.6\ ms^{-1}$



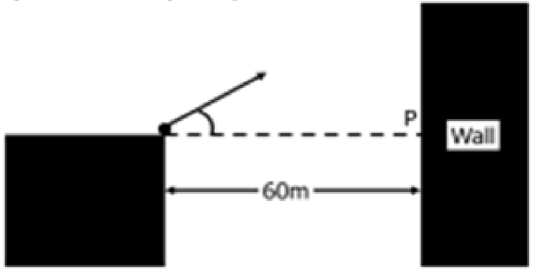
theorem ?

Pythagoras'

$|\vec{V}|^2 = \sqrt{|\vec{V}_x|^2 + |\vec{V}_y|^2}$

$|\vec{V}| \approx 29.83\ ms^{-1}$

8. **(PSPM 11/12)**



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(a) How much time does it take to hit the wall?

(b) What is the distance between P and the position the ball strike the wall?

(c) What is the speed of the ball when it strikes the wall?

$(-5)^2 = 25$

$-(5)^2 = -25$

wrong

Thank you!

3rd November 2021

18/19

6

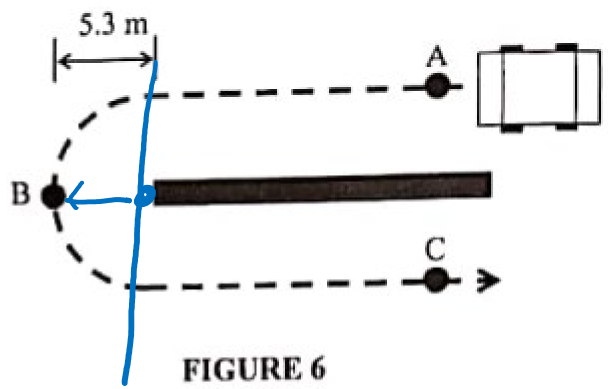


FIGURE 6
RAJAH 6

FIGURE 6 shows the top view of a U turn at a road divider. The radius of the circular curve is 5.3 m. A 950 kg car maintains a speed of 15.3 m s^{-1} along points A to C.

(a) Copy the path and indicate the directions of velocity and acceleration of the car at point B.

90° from the radius

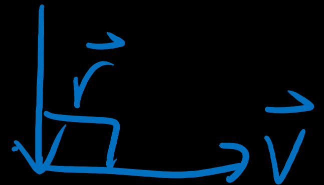
toward the centre of circle

$r = 5,3 m$

$V = 15,3 ms^{-1}$

$m = 950 kg$

$F_{friction} = F_{centripetal}$



6

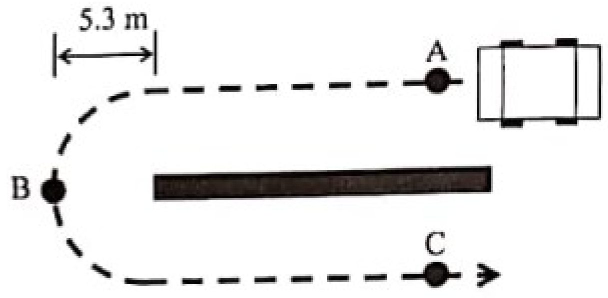


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FIGURE 6 shows the top view of a U turn at a road divider. The radius of the circular curve is 5.3 m. A 950 kg car maintains a speed of 15.3 m s^{-1} along points A to C.

(b) Calculate the centripetal acceleration of the car at point B.

$F = m a_c$

$a_c = \boxed{\frac{v^2}{r}}$ 15.3 5.3

6

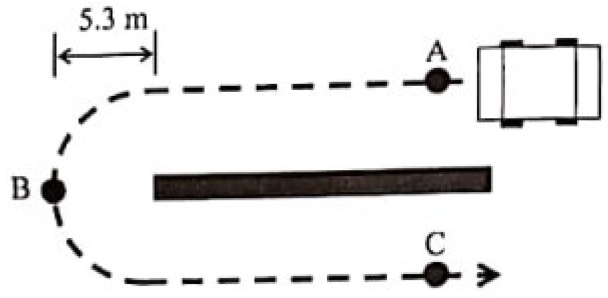


FIGURE 6
RAJAH 6

FIGURE 6 shows the top view of a U turn at a road divider. The radius of the circular curve is 5.3 m. A 950 kg car maintains a speed of 15.3 m s^{-1} along points A to C.

(c) Calculate the centripetal force on the car at point B.

$F_c = \cancel{ma_c}\ ma_c$

(b) An 800 kg satellite is orbiting the Earth a circular path. The weight of the satellite while orbiting is half of its weight on Earth. Determine the (Given: mass of the Earth $M = 6.0 \times 10^{24}$ kg and radius of the Earth $R = 6.4 \times 10^{6}$ m)

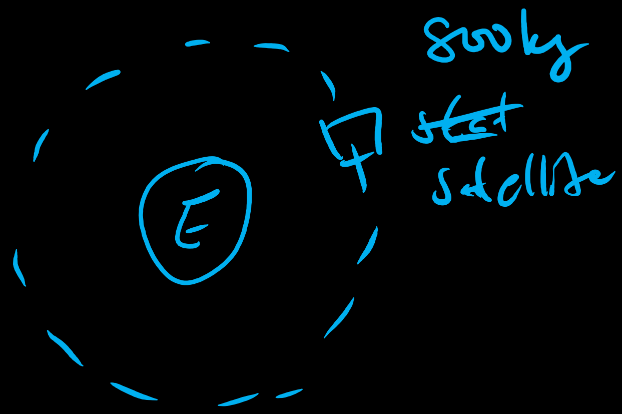
Sebuah satelit 800 kg mengorbit Bumi dalam satu lintasan membulat. Berat satelit ketika mengorbit adalah separuh daripada beratnya di Bumi. Tentukan (Diberi: jisim Bumi $M = 6.0 \times 10^{24}$ kg dan jejari Bumi $R = 6.4 \times 10^{6}$ m)

(i) altitude of the satellite.

altitud satelit.

(ii) speed of the satellite in the orbit.

laju satelit di orbit.



$W(r = r_{orbit}) = \frac{1}{2} W(r = 0)$

measured from the Earth's surface

① Altitude

② Speed

(b) An 800 kg satellite is orbiting the Earth a circular path. The weight of the satellite while orbiting is half of its weight on Earth. Determine the
(Given: mass of the Earth $M = 6.0 \times 10^{24}$ kg and radius of the Earth $R = 6.4 \times 10^{6}$ m)

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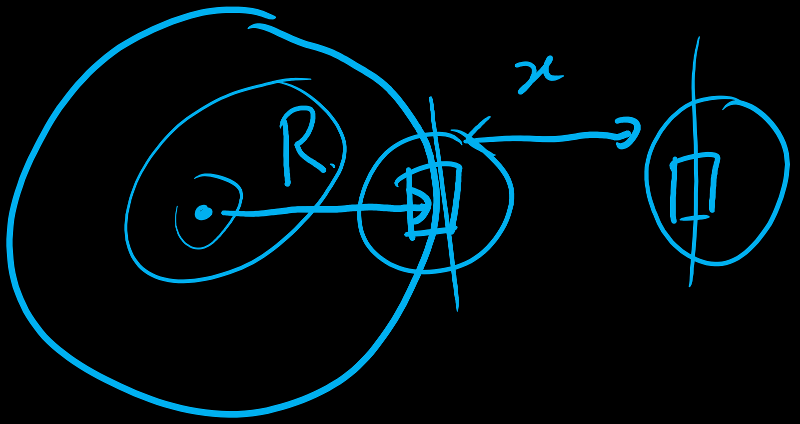
(i) altitude of the satellite.
altitud satelit.

(ii) speed of the satellite in the orbit.
laju satelit di orbit.

$W(r_{orbit} = r) = \frac{1}{2} W(r = ground)$ — 1

Newton's Law of gravitation

$$F_g = W = \frac{G m_1 m_2}{r^2} \; ; \; m_E = m_1, \; m_2 = m_s.$$



$$\frac{\cancel{G} \cancel{m_s} \cancel{m_E}}{(R+x)^2} = \frac{1}{2} \frac{\cancel{G} \cancel{m_s} \cancel{m_E}}{(R)^2}$$

$$\frac{1}{(R+x)^2} = \frac{1}{(2(R)^2)} \Rightarrow (R+x)^2 = (2R)^2$$

$$R^2 + x^2 + 2Rx = 4R^2$$ 2

$r = R$.

altitude, $r + x$

(b) An 800 kg satellite is orbiting the Earth a circular path. The weight of the satellite while orbiting is half of its weight on Earth. Determine the
(Given: mass of the Earth $M = 6.0 \times 10^{24}$ kg and radius of the Earth $R = 6.4 \times 10^{6}$ m)

Sebuah satelit 800 kg mengorbit Bumi dalam satu lintasan membulat. Berat satelit ketika mengorbit adalah separuh daripada beratnya di Bumi. Tentukan
(Diberi: jisim Bumi $M = 6.0 \times 10^{24}$ kg dan jejari Bumi $R = 6.4 \times 10^{6}$ m)

(i) altitude of the satellite.

altitud satelit.

(ii) speed of the satellite in the orbit.

laju satelit di orbit.

V

$F_g = F_c$ — 1

$$\frac{G m_1 m_2}{r^2} = \boxed{\frac{m_2 V^2}{r}}$$

altitude of orbit

Rearranging eqn 2

$$x^2 + 2Rx + R^2 - 4R^2 = 0$$

$$\underbrace{x^2 + 2Rx - 3R^2 = 0}_{\text{Quadratic formulae}}$$

$x = 2.63 \times 10^{6}$ m

$V = 6.66 \times 10^{3}$ m s^{-1}

19/20

6 A 16 g ball is swung vertically using a 0.5 m string. Calculate the

Satu bola 16 g dihayun menegak dengan menggunakan satu tali 0.5 m. Hitung

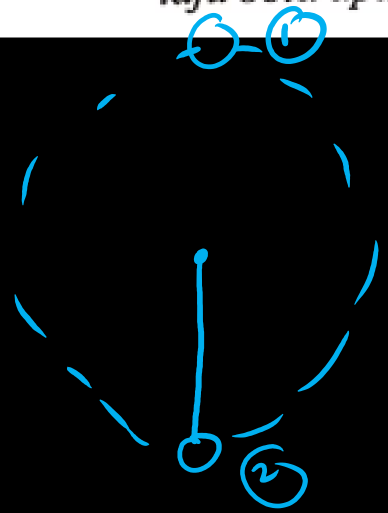
(a) minimum tension in the string if the speed of the ball is 1.5 m s^{-1}.

tegangan minimum tali jika laju bola ialah 1.5 m s^{-1}.

(b) speed of the ball when the string breaks.

laju bola apabila tali putus.

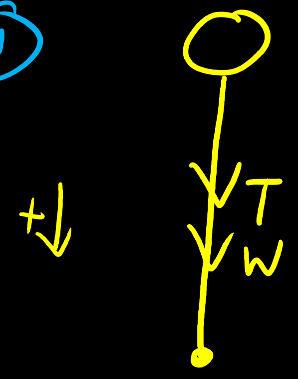
$$\boxed{\sum F_y = F_c = \frac{mv^2}{r}}$$



$l = 0.5m$

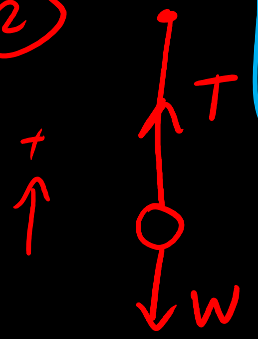
$m = 16g$

1



$\sum F_y = T + W$

2



$\sum F_y = T - W$

1

$$\frac{mv^2}{r} = T + W$$

$$\frac{(0.016)(1.5)^2}{0.5} = T + (0.016)(9.81)$$

$$T = -0.085N$$

2

$$\cancel{\frac{mv^2}{r} + W = T}$$

$$\cancel{T = \frac{(0.016)(1.5)^2}{0.5} + (0.016)(9.81)}$$

$$\cancel{= 0.229N}$$

6 A 16 g ball is swung vertically using a 0.5 m string. Calculate the

Satu bola 16 g *dihayun menegak dengan menggunakan satu tali* 0.5 m. *Hitung*

(a) minimum tension in the string if the speed of the ball is 1.5 m s^{-1}.

tegangan minimum tali jika laju bola ialah 1.5 m s^{-1}.

(b) speed of the ball when the string breaks. $\rightarrow T = 0$

laju bola apabila tali putus.

$F_c = W$

$\frac{\cancel{m}v^2}{r} = \cancel{m}g$

$v^2 = gr$

$v = \sqrt{9.81(0.5)}$

$v = 2.215 \text{ ms}^{-1}$

7 A 120 kg satellite is orbiting the Earth at an altitude of 190 km. The radius and mass of the Earth are 6.4×10^6 m and 5.98×10^{24} kg respectively. Calculate the

Satu satelit 120 kg *mengorbit bumi pada altitud* 190 km. *Jejari dan jisim bumi masing-masing ialah* 6.4×10^6 m *dan* 5.98×10^{24} kg. *Hitung*

(a) gravitational potential energy of the satellite.

tenaga keupayaan graviti satelit.

(b) period of the satellite.

tempoh satelit.

(c) change in the speed of the satellite for it to break-free from the orbit.

perubahan laju satelit untuk ia terlepas dari orbit.

$$E_{gp} = -\frac{(6.67)(10^{-11})(5.98\times10^{24})(120\text{kg})}{((6.4\times10^3)+(190))\times10^3}$$

$$E_{gp} = -7.263(10^9)\text{J}$$

7)a) $F = \frac{Gm_1m_2}{r^2}$

$\Delta \vec{W} = -\vec{F}\cdot\Delta\vec{r}$

$\Delta W = \Delta E$

$\Delta E = E_{gp} = (F)(r)$

$E_{gp} = -\frac{Gm_1m_2}{r^2}(r)$

$E_{gp} = -\frac{Gm_1m_2}{r}$

$F_c = \frac{mv^2}{r}$

$v = \frac{2\pi r}{T}$

7).b)

$F_g = \frac{Gm_1m_2}{r^2}$

$F_g = F_c$

$v^2 = \frac{GM}{r}$

$T^2 = \frac{4\pi^2}{GM}r^3$

$T = 2\pi\sqrt{\frac{r^3}{GM}}$

7 A 120 kg satellite is orbiting the Earth at an altitude of 190 km. The radius and mass of the Earth are 6.4×10^6 m and 5.98×10^{24} kg respectively. Calculate the

Satu satelit 120 kg *mengorbit bumi pada altitud* 190 km. *Jejari dan jisim bumi masing-masing ialah* 6.4×10^6 m *dan* 5.98×10^{24} kg. *Hitung*

(a) gravitational potential energy of the satellite.

tenaga keupayaan graviti satelit.

(b) period of the satellite.

tempoh satelit.

(c) change in the speed of the satellite for it to break-free from the orbit.

perubahan laju satelit untuk ia terlepas dari orbit.

V_{esc}.

$$\Delta V = V_f - V_i$$

$$V_{esc} = \sqrt{\frac{2Gm}{r}}$$

$$V = \sqrt{\frac{Gm}{r}}$$

$$T = 2\pi\sqrt{\frac{((190000) + 6.4(10^6))^3}{6.67(10^{-11})(5.98\times10^{24})}}$$

$$T = 5322.24\,s$$

$$\Delta V = \sqrt{\frac{2Gm}{r}} - \sqrt{\frac{Gm}{r}}$$

$$= \sqrt{2}\left(\sqrt{\frac{Gm}{r}}\right) - \left(\sqrt{\frac{Gm}{r}}\right)$$

$$= 0.4142\left(\sqrt{\frac{Gm}{r}}\right)$$

THANK YOU!

8^{th} November 2021

Chapter 4
Past Year 18/19 & 19/20

4

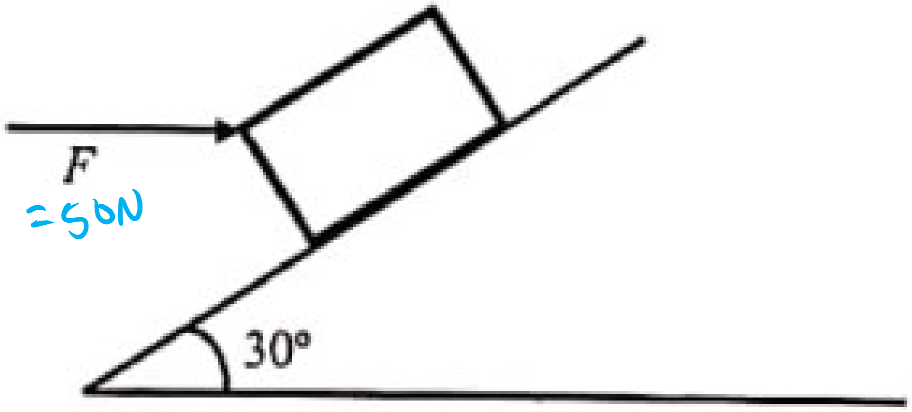


FIGURE 4
RAJAH 4

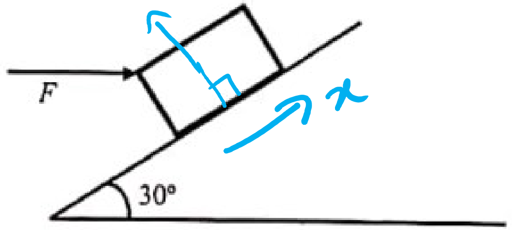
($F_f = 0$)

FIGURE 4 shows an object of mass 2.0 kg placed on a rough plane inclined at 30° with the horizontal. The coefficient of kinetic friction between the object and the plane surface is 0.25. A constant horizontal force F = 50 N acts on the object and pushes it along the inclined plane with acceleration a.

(a) Sketch a free body diagram showing all the forces acting on the object.

(b) Calculate the acceleration of the object.

4



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RAJAH 4

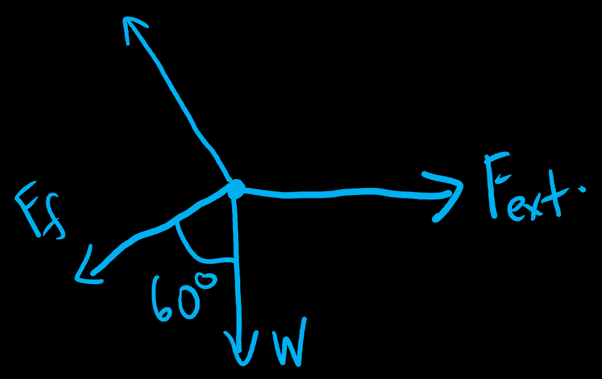
FIGURE 4 shows an object of mass 2.0 kg placed on a rough plane inclined at 30° with the horizontal. The coefficient of kinetic friction between the object and the plane surface is 0.25. A constant horizontal force $F = 50$ N acts on the object and pushes it along the inclined plane with acceleration a.

(a) Sketch a free body diagram showing all the forces acting on the object.

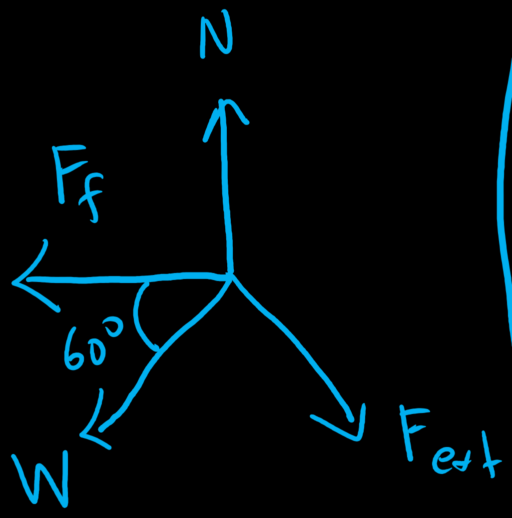
(b) Calculate the acceleration of the object.

W, N, T, F_f

a)



⇒



B)

$$x: F_f + W\cos 60 - F_{ext}\cos 30 = \sum F_x$$

$$y: N - W\sin 60 - F_{ext}\sin 30 = \sum F_y.$$

$$\sum F_y = 0$$

$$N = W\sin 60 + F_{ext}\sin 30.$$

$$= 19.62\sin 60 + 50\sin 30$$

$$\approx 42\ N$$

$$F_f = \mu N \approx 0.25(42)$$

$$F_f \approx 10.5N$$

4

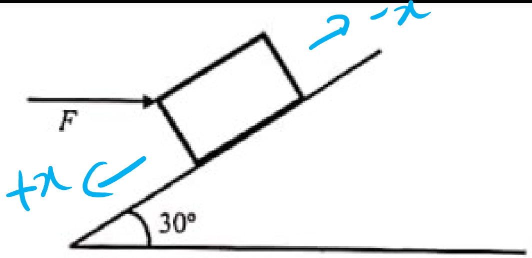


FIGURE 4
RAJAH 4

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(a) Sketch a free body diagram showing all the forces acting on the object.

(b) Calculate the acceleration of the object.

$$F_f + W\cos 60 - F_{ext}\cos 30 = \sum F_x = m a_x$$

$$\frac{10.5 + 2(9.81)\cos 60 - 50\cos 30}{2} = a_x$$

$$a_x \approx -11.49\ ms^{-2}$$

$$\boxed{a_x = -11.49\ ms^{-2}}$$

4

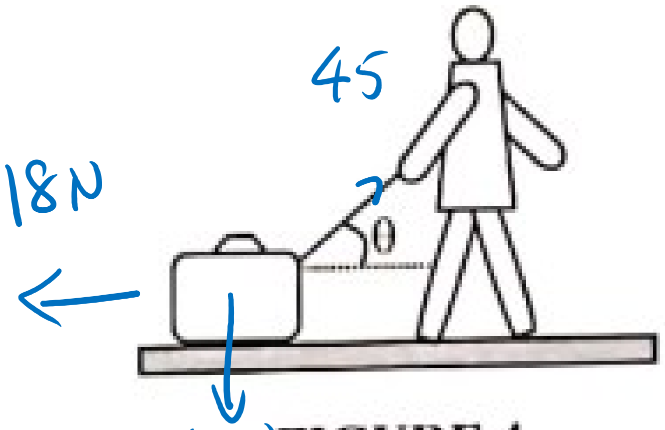


FIGURE 4
***RAJAH* 4**

$\sum F = F_{nett} = 0$

A man drags a 23 kg suitcase with a 45 N force at constant speed as shown in **FIGURE 4**. The frictional force on the suitcase is 18 N. With the help of a free-body diagram, calculate the coefficient of kinetic friction between the suitcase and floor.

4

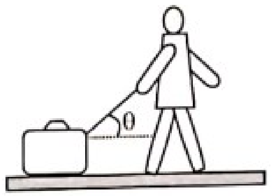


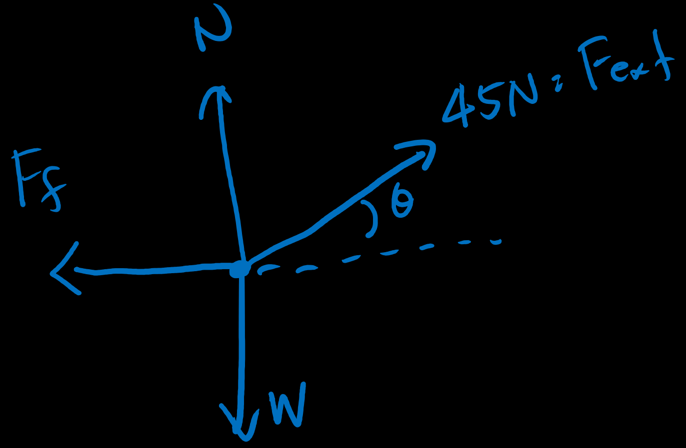
FIGURE 4
RAJAH 4

A man drags a 23 kg suitcase with a 45 N force at constant speed as shown in **FIGURE 4**. The frictional force on the suitcase is 18 N. With the help of a free-body diagram, calculate the coefficient of kinetic friction between the suitcase and floor.

$$\sum F_x = 45\cos\theta - F_f = 0 \quad \text{— (1)}$$

$$\sum F_y = N - W + 45\sin\theta = 0$$

$$F_f = \mu N \Rightarrow \mu = \frac{F_f}{N}$$



$$\mu = \frac{18}{W - 45\sin\theta} = \frac{18}{23(9.81) - 45\sin 66.422}$$

$$F_f = 45\cos\theta = 18$$

$$\theta \simeq 66.422^\circ$$

$$\mu \simeq 0.098$$

5 (a)

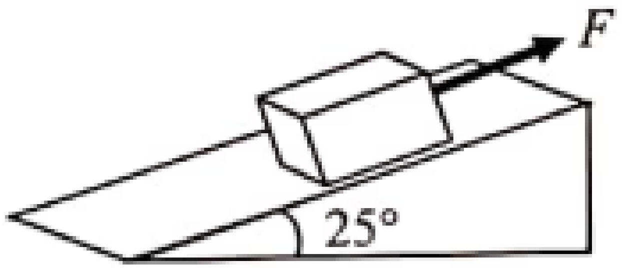


FIGURE 5
***RAJAH* 5**

FIGURE 5 shows a 15 kg block being pulled by a 100 N force at an initial speed of 2 m s^{-1} up an inclined plane. The block travels a distance of 6.2 m parallel to the inclined plane. The coefficient of kinetic friction is 0.14. By using the work-energy theorem, calculate the change in the kinetic energy of the block.

(b) A 120 kg motorcycle accelerates uniformly from rest to 25 m s^{-1} in 5 s. Calculate the instantaneous power of the motorcycle at time $t = 3$ s.

5 (a)

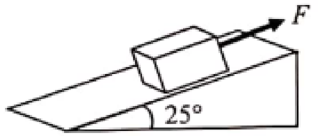


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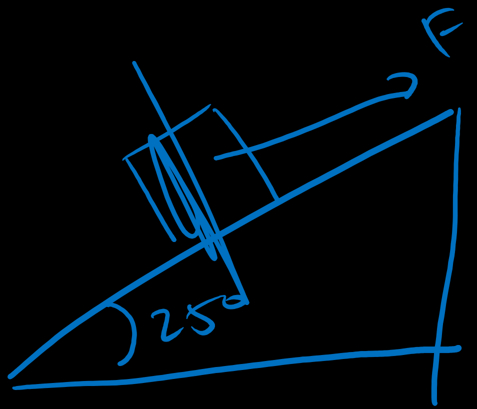
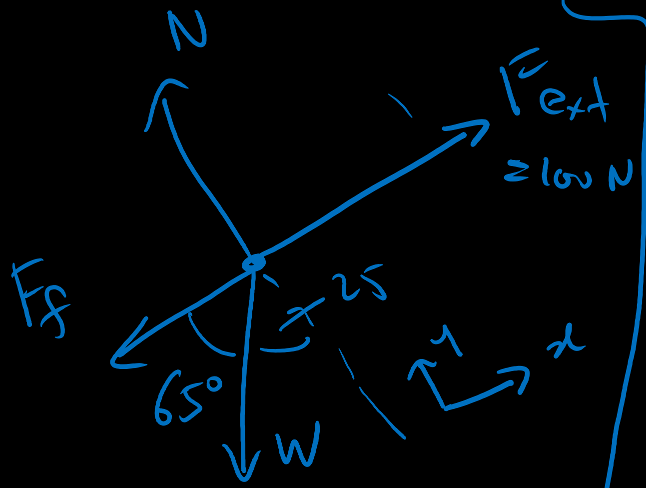
FIGURE 5 shows a 15 kg block being pulled by a 100 N force at an initial speed of 2 m s^{-1} up an inclined plane. The block travels a distance of $\boxed{6.2\text{ m}}$ parallel to the inclined plane. The coefficient of kinetic friction is 0.14. By using the work-energy theorem, calculate the (change in the kinetic energy of the block.) → work-energy theorem

(b) A 120 kg motorcycle accelerates uniformly from rest to 25 m s^{-1} in 5 s. Calculate the instantaneous power of the motorcycle at time $t = 3$ s.





$$\left(\sum F_x = F_{ext} - F_f - W\cos 65\right) \times s$$

$$\sum F_y = N - W\cos 25 = 0$$

$$N = W\cos 25$$

$$F_f = \mu N = \mu mg\cos 25$$

$$W = \Delta E_k = \sum F \cdot s$$

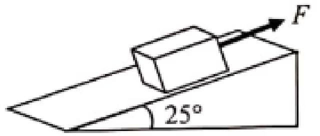
$$100N - 0.14(15)(9.81)\cos 25 - 15(9.81)\cos 65 = \sum F_x$$

$$\sum F_x \approx 19.14\text{ N}$$

$$\Delta E_k = W = \left(\sum F_x\right)(s) \approx (19.14)(6.2)$$

$$\boxed{\Delta E_k \approx 118.668\text{ J}}$$

5 (a)



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RAJAH 5

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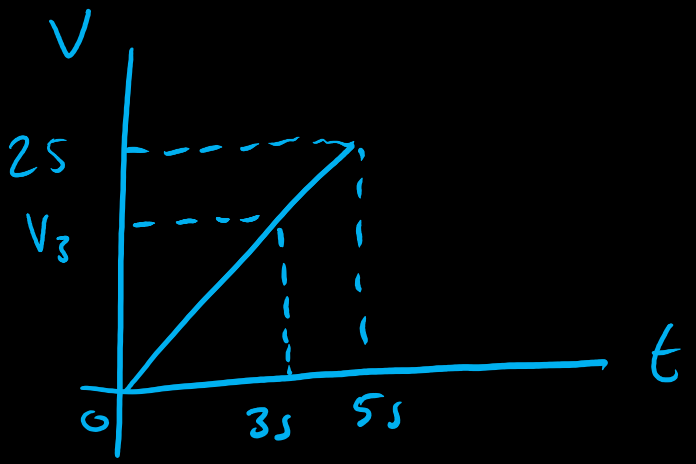
(b) A 120 kg motorcycle accelerates uniformly from rest to 25 m s^{-1} in 5 s. Calculate the instantaneous power of the motorcycle at time $t = 3$ s.

b) $P_{instant} = F \cdot V$

$$P = \frac{W}{t} = \frac{F \cdot S}{t} = F \cdot V$$

$u = 0\ ms^{-1},\ V = 25\ ms^{-1},\ t = 5\,s$



$F = ma$
$= 120(5)$
$= 600\ N$

$V_3 = ?$

$$m = \frac{25-0}{5-0} = 5\ \cancel{ma}\ ms^{-2} = a$$

$y = mx + \cancel{c}^{\,0}$

$y = 5(3)$

$V_3 = 15\ ms^{-1}$

$P_{ins} = 600(15)$

$\boxed{P_{ins} = 9000\ W = 9\ kW}$

Thank you!

9th November 2021

18/19 Chapter 9 & 10

8 (a)

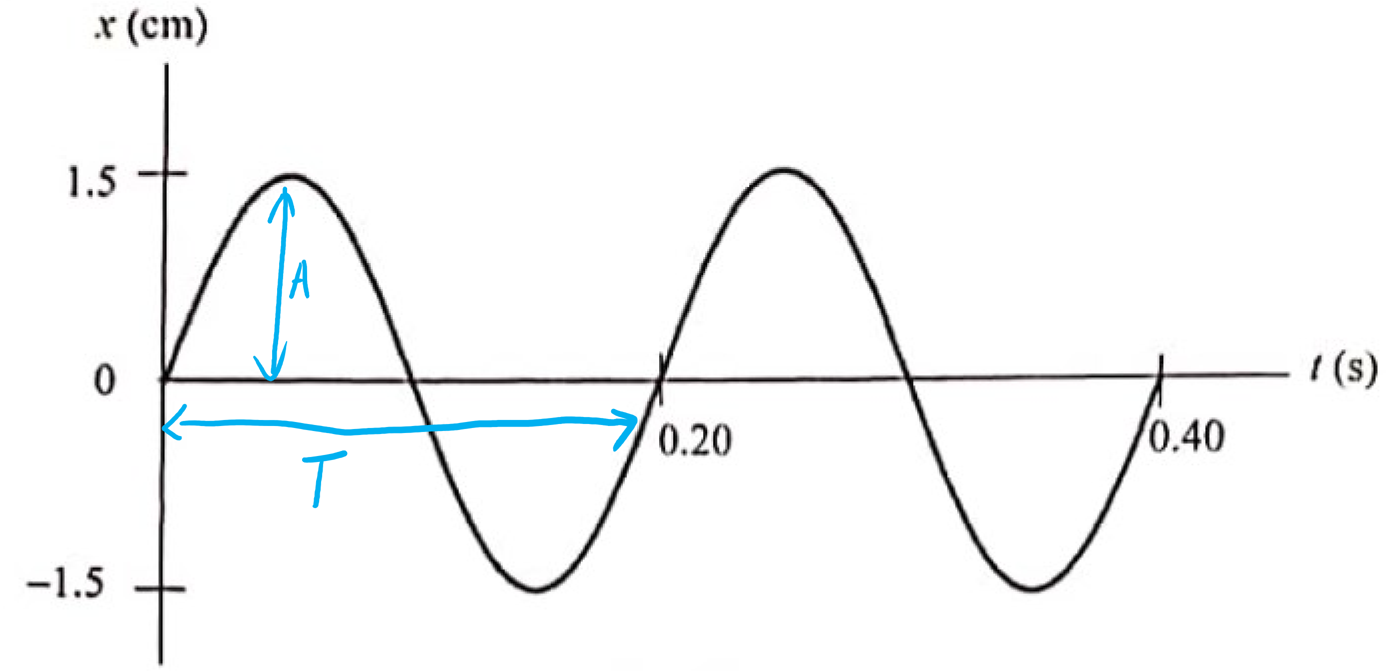


FIGURE 8

A 0.75 kg mass is attached to one end of a horizontal spring while the other end is fixed. **FIGURE 8** shows a graph of displacement versus time of the system which freely oscillates in a simple harmonic motion. Determine the

(i) equation of the displacement as a function of time.

(ii) velocity and acceleration of the oscillation at any time t.

(iii) maximum speed and acceleration of the oscillation.

2 common cases

- Simple pendulum
- spring system

G.E.

$x = A \sin(\omega t) \leftarrow$

$A = 1.5\,cm.$

$T = 0.2\,s.$

$x(t) = 1.5 \sin(\omega t)$

$\omega(T) = \frac{2\pi}{T} = 10\pi \text{ rad s}^{-1}$

$x(t) = 1.5 \sin(10\pi t)$

where A is in cm, t is in seconds.

8 (a)

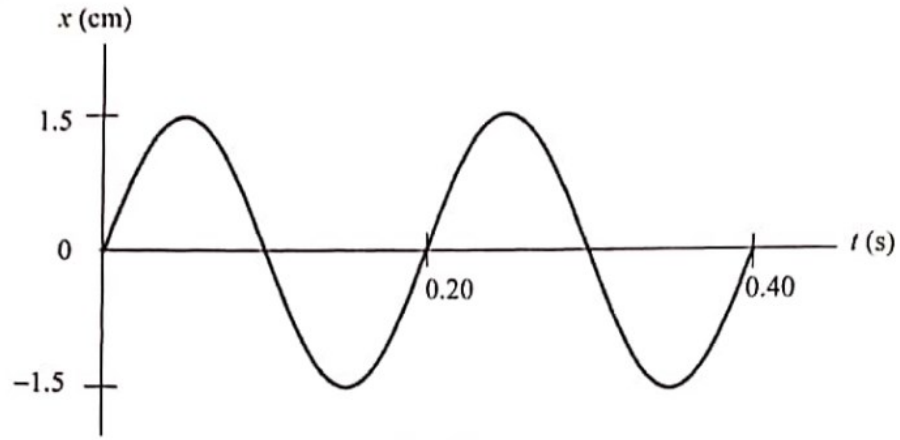


FIGURE 8

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(i) equation of the displacement as a function of time.

(ii) velocity and acceleration of the oscillation at any time t.

(iii) maximum speed and acceleration of the oscillation.

$$x(t) = 1.5 \sin(10\pi t)$$

$$V = \frac{d}{dt}(x(t)) = A\omega \cos(\omega t)$$

$$V = 1.5(10\pi)\cos(10\pi t)$$

$$v(t) = 15\pi \underbrace{\cos(\pi(10)t)}_{=1 \text{ when } V_{max}.}$$

$$V_{max} = 15\pi \text{ cms}^{-1}$$

$$a = \frac{d}{dt}[v(t)] = \frac{d}{dt}[15\pi \cos(10\pi t)]$$

$$a(t) = 10\pi(15\pi)(-\sin(10\pi t))$$

$$a(t) = -150\pi^2 \underbrace{\sin(10\pi t)}_{1}$$

$$a_{max} = -150\pi^2 \text{ cms}^{-2} \#$$

(b) A simple pendulum has a length of 1.5 m and mass of bob 10 g.

l m

(i) Calculate the period of the pendulum.

(ii) If you want the period of the pendulum to be 1.0 s, calculate the new length of pendulum.

(iii) If the bob is replaced by a new bob of mass 40 g, will the period remains the same? Justify. → T independent of mass ⇒ period remains the same

2 cases of SHM
→ simple pendulum
→ spring system

$\omega(c)$ → physical variable
→ $\boxed{\text{pendulum} \to \text{length}}$
→ spring → Hooke's constant

i) $\omega(l) = \sqrt{\frac{g}{L}}$

$\omega = \frac{2\pi}{T}$

$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{l}{g}}$

$T(l = 1.5) = 2\pi\sqrt{\frac{1.5}{9.81}}$

$T \approx 2.456\,s$

ii) $T = 1s$

in ms^{-2}

$l = g\left(\frac{T}{2\pi}\right)^2 = (9.81)\left(\frac{1}{2\pi}\right)^2$

$l = 0.248\,m$

9 (a) A progressive wave is described by $y = 5\sin 2\pi\left(10t - \frac{x}{5}\right)$ where x, y are in cm and t in s. Calculate the

(i) speed of the wave.

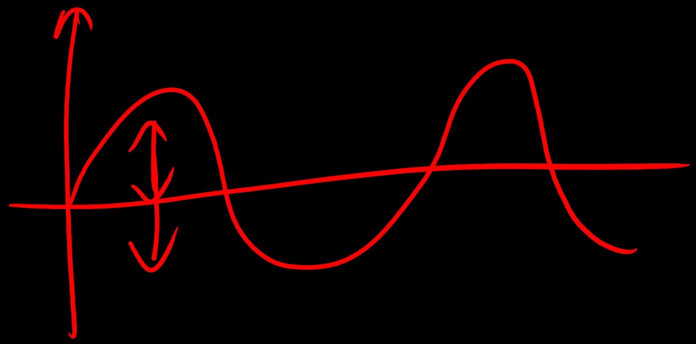
(ii) vibrational velocity at time $t = 0$ s, for the particle is at $x = 5.0$ cm.

a) $v = f\lambda$

$f(\omega)$ angular freq

$\lambda(k)$ wave number

ii)

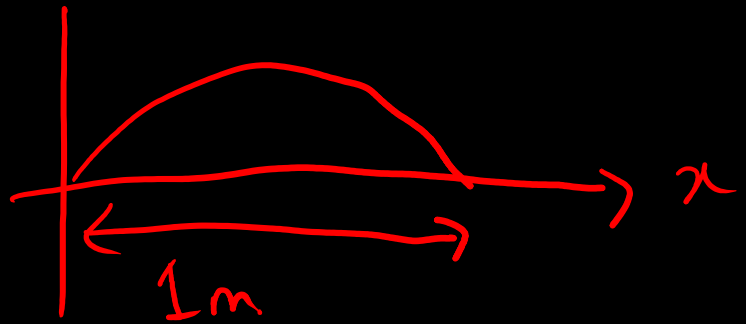


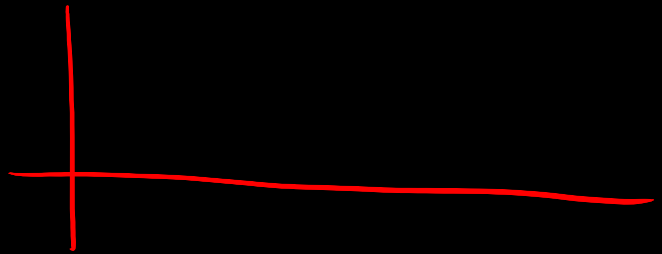
$\frac{dy}{dt}$!

(b) A wire of mass 30 g is stretched between two points 100 cm apart with tensional force of 70 N. When the wire is plucked, standing waves are formed in the wire.

(i) Calculate the fundamental frequency and the third overtone frequency of the wire.

(ii) If the tensional force of wire is doubled, determine the new fundamental frequency.





fundamental

third overtone

$L = \frac{1}{2}\lambda$

$V = f\lambda \Leftarrow v(T, \mu)$

(c) A stationary loudspeaker radiates sound with a frequency of 1000 Hz uniformly in all directions. At a distance of 4.0 m the intensity of sound is 0.95 W m^{-2}. Calculate the

(i) power of the loudspeaker.

(ii) frequency of the sound heard by a child if he approaches the sound at the speed of 10 m s^{-1}.

(Speed of sound = 330 m s^{-1})
(*Laju bunyi* = 330 m s^{-1})

$I(r)$ equation?

Doppler effect

Thank you!

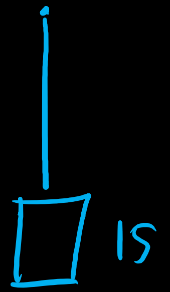
10th November 2021

Chapter 11 & 12 – 18/19 paper

10 An aluminium wire, initially 2.45 m long and diameter of 1.5 mm, is suspended from a rigid support with a load of 15 kg attached to its lower end. Young's modulus of aluminium is 7.0×10^{10} N m^{-2}. Calculate the

(a) extension of the wire.

(b) strain energy stored in the wire.



$\delta = \frac{F}{A}$

$\epsilon = \frac{e}{l_0}$

$Y = \frac{\delta}{\epsilon}$

$A = \pi r^2$

$l_0 = 2.45 m$

$d = 1.5 mm$

$m = 15 kg$

$Y = 7(10^{10}) Nm^{2}$

$Y = \delta\left(\frac{1}{\epsilon}\right)$ ✓

$Y = \frac{F}{A}\left(\frac{l_0}{e}\right)$

$\delta = \frac{F}{A}$

$\delta = \frac{W}{\pi r^2}$

$\delta = \frac{mg}{\pi\left(\frac{d}{2}\right)^2}$

$Y = \delta\left(\frac{l_0}{e}\right)$

$\frac{Y}{\delta} = \frac{l_0}{e}$

$e = \frac{\delta l_0}{Y}$

$e = \frac{mg}{\pi\left(\frac{d}{2}\right)^2}\left(\frac{2.45}{7(10)^{10}}\right)$

$e = \frac{(15)(9.81)(2.45)}{(\pi)(7)(10^{10})\left(\frac{1.5\times10^{-3}}{2}\right)^2}$

$e \simeq 2.914(10^{-3}) m$

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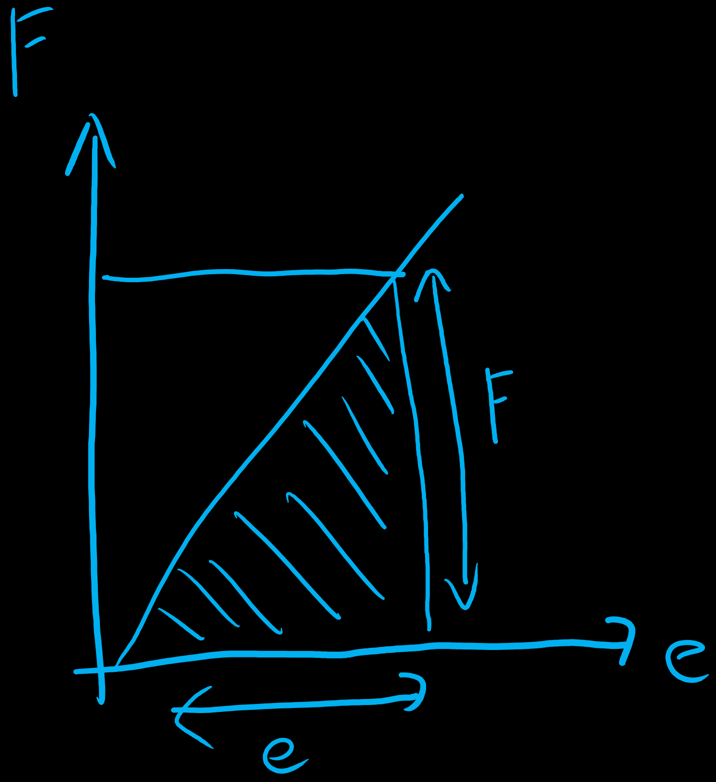
(a) extension of the wire.

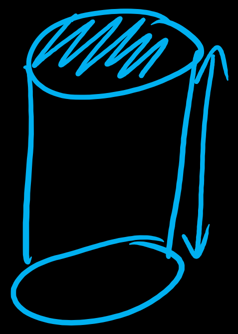
(b) strain energy stored in the wire.



$$W = \frac{1}{2}Fe$$

$$= \frac{1}{2}(15)(9.81)(2.914 \times 10^{-3})$$

$$W = 0.214\,\mathrm{J} = U.$$



11 The dimension of an aluminium wire at room temperature (27°C) is 150 m long and cross sectional area of $3.0 \times 10^{-6}\ \text{m}^2$. It is then melted to form a spherical ball. If the coefficient of linear thermal expansion of the aluminium is $22.2 \times 10^{-6}\ \text{m K}^{-1}$, calculate the

(a) volume of the spherical ball at room temperature.

(b) change in the volume of the sphere if it is heated to 200°C.

(c) change in the volume of the sphere if it is cooled to –7°C.

at 27°C : $l = 150\ \text{m}$, $A = 3(10^{-6})\ \text{m}^2$

↓

spherical ball

$\alpha = 22.2 \times 10^{-6}\ \text{mK}^{-1}$

$V_{wire} = V_{sphere}$

(a) $V_{sphere} = V_{wire}$

$= (A)(l)$

$= 3(10^{-6})(150)$

$\approx \cancel{45}\ 4.5(10^{-4})\ \text{m}^3$

11 The dimension of an aluminium wire at room temperature (27°C) is 150 m long and cross sectional area of $3.0 \times 10^{-6}\ m^2$. It is then melted to form a spherical ball. If the coefficient of linear thermal expansion of the aluminium is $22.2 \times 10^{-6}\ K^{-1}$, calculate the

(a) volume of the spherical ball at room temperature.

(b) change in the volume of the sphere if it is heated to 200°C.

(c) change in the volume of the sphere if it is cooled to −7°C.

ΔT
$= 173°C$
$= \underline{173 K}$

$V_{sphere} = 4.5(10^{-4})\ m^3$

$\alpha = 22.2(10^{-6})\ K^{-1}$

untuk volume,

$\gamma = 3\alpha$

$\Delta T = T_f - T_i = 173°C$

b)

$\frac{\Delta V}{V}\left(\frac{1}{\Delta T}\right) = \gamma$

$\Delta V = \gamma \Delta T V$

$\Delta V = 3\alpha \Delta T V$

$\Delta V = 3(22.2(10^{-6}))(173)(4.5)(10^{-4})$

$\Delta V = 5.184(10^{-6})\ m^3$

c)

$\Delta V (\Delta T = -34 K)$

$= 3\alpha(\Delta T)(V)$

$\simeq -1.01(10^{-6})\ m^3$

Thank you!

15 November 2021

Past Year Discussion 18/19

Chapter 13 & 14

12 The pressure of a 0.02 m^3 monoatomic gas in a container is 2 atm. The mass of each atom is 3.351×10^{-23} g. Calculate the

(a) (average translational kinetic energy of the gas.)

(b) $f=3$ (internal energy) of the gas.

(c) v_{rms} value at 27°C.

2atm = 202650 Pa.

12) a) $pV = nRT$

Pa. m^3 # of moles gas constant K.

$k(R) = \frac{R}{N_A}$

a)

$E_k = \frac{3}{2} kT$

$= \frac{3}{2N_A} RT$

$= \frac{3}{2N_A} \left(\frac{pV}{n} \right)$

$= \frac{3}{2} pV \left(\frac{1}{N_A n} \right)$

$= \frac{3}{2} pV \left(\frac{1}{N} \right)$

assume $N = 1$

$E_k = \frac{3}{2} pV$

$= \frac{3}{2}(202650)(0.02)$

$E_k = 6079.5\text{ J}$ ##

b) $U = \frac{f}{2} N_A k_B T$

$= \frac{3}{2} N_A k_B T$

$U = E_k = 6079.5\text{J}$

12 The pressure of a 0.02 m^3 monoatomic gas in a container is 2 atm. The mass of each atom is 3.351×10^{-23} g. Calculate the

(a) average translational kinetic energy of the gas.

(b) internal energy of the gas.

(c) v_{rms} value at 27°C.

c) $E_k = 6079.5 J$

$\frac{1}{2}mv^2 = \frac{3}{2}kT.$ equipartition theorem

$V_{rms}^2 = 3\frac{kT}{m}$

$V_{rms} = \sqrt{3\frac{kT}{m}}$

$V_{rms} = \left[\frac{3(1.38)(10^{-23})(27+273)}{3.351 \times 10^{-23} \times 10^{-3}}\right]^{1/2}$

$V_{rms} = 608.889 ms^{-1}$ #.

13 One mole of an ideal gas is compressed isothermally from $4V$ to V. The work done on the gas is 4.5×10^3 J.

(a) Sketch a p-V graph for this process.

(b) Calculate the heat transferred during the compression. Is the heat absorbed or released by the system?

(c) Calculate the isothermal process temperature.

Homework

Thank you!

16 November 2021
Chapter 9 & 10, PYQ 19/20

$E_T = E_k + E_p$.

$E_T = \frac{1}{2} m\omega^2 A^2$ — ①

$E_p = \frac{1}{2} m\omega^2 x^2$ — ②

$E_k = \frac{1}{2} m\omega^2 (A^2 - x^2)$

8 (a)

spring ×

simple pendulum ×

$\boxed{\text{SHM.}}$

EK

Ep.

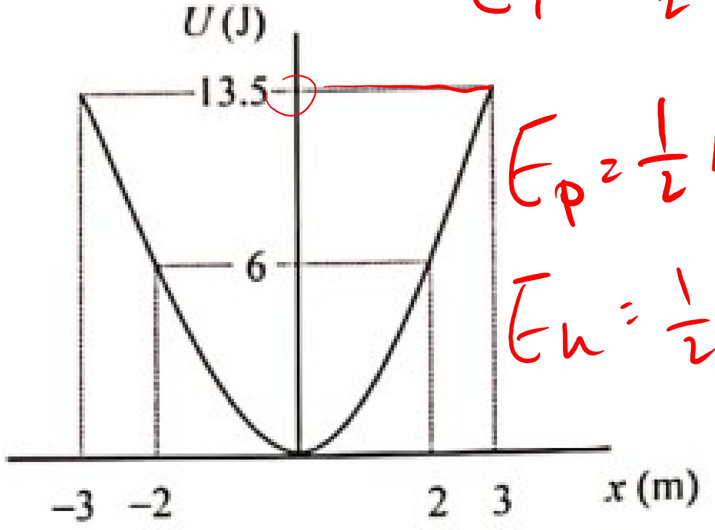


FIGURE 8
RAJAH 8

FIGURE 8 shows the potential energy of a 0.5 kg object that undergoes a simple harmonic motion. Determine the

(i) velocity when time $t = 2$ s. $v(x) = \pm\omega(A^2 - x^2)^{1/2}$; $v(t) = \frac{dx}{dt} = \omega A \cos(\omega t)$

(ii) kinetic energy of the object when displacement $x = 1.5$ m.

$\boxed{E_k(x)}$; $E_k(t)$

8 (a)

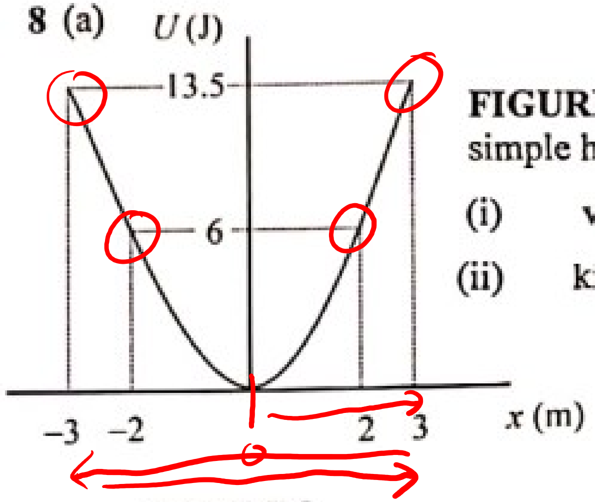


FIGURE 8
RAJAH 8

FIGURE 8 shows the potential energy of a 0.5 kg object that undergoes a simple harmonic motion. Determine the

(i) velocity when time $t = 2$ s.

(ii) kinetic energy of the object when displacement $x = 1.5$ m.

$\omega \approx 2.449 \text{ rads}^{-1}$

$v(t) = \omega A \cos \omega t$

$= (\sqrt{6})A \cos(\sqrt{6}t)$

how?

$A = 3$ m

radians.

$v(t) = \frac{d}{dt}[A \sin \omega t] = \omega A \cos(\omega t)$

$v(t) = 3(\sqrt{6}) \cos(\sqrt{6} \times 2)$

$v(t = 2s) = \boxed{1.36 \text{ ms}^{-1}}$

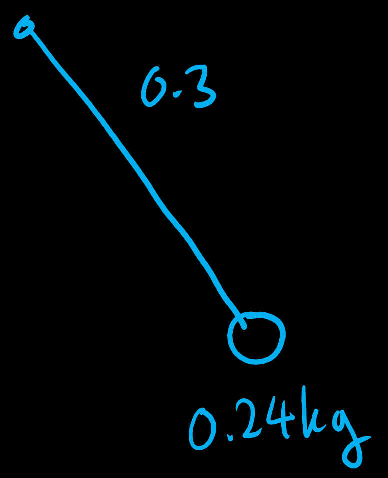
$E_p = \frac{1}{2} m \omega^2 x^2$

$\omega^2 = \frac{2E_p}{m x^2} = \frac{2(6)}{(0.5)(2)^2}$

ii) $E_k(x = 1.5) = \frac{1}{2} m \omega^2 (A^2 - x^2)$

$E_k = \frac{1}{2}(0.5)(\sqrt{6})^2(3^2 - 1.5^2) \approx \boxed{10.125 \text{ J.}}$

(b) An oscillating pendulum has length 0.3 m and 240 g bob. If the total energy is 0.06 J, calculate the amplitude of the oscillation.



$E_T = 0.06\text{ J}.$

$A?$

$E_T = \frac{1}{2} m\omega^2 A^2$ — (1)

For simple pendulum,

$\omega(l) = \sqrt{\frac{g}{l}}$ — (2)

Rearrange & sub (2) into (1)

$E_T = \frac{1}{2} m \left(\frac{g}{l}\right) A^2$

$A^2 = \frac{2 l E_T}{mg}$

$A^2 = \frac{2(0.3)(0.06)}{(0.24)(9.81)}$

$\boxed{A \approx 0.1237\text{ m.}}$

$m_s = 920g$; $l = 3m$; $T = 15N.$

9 (a)

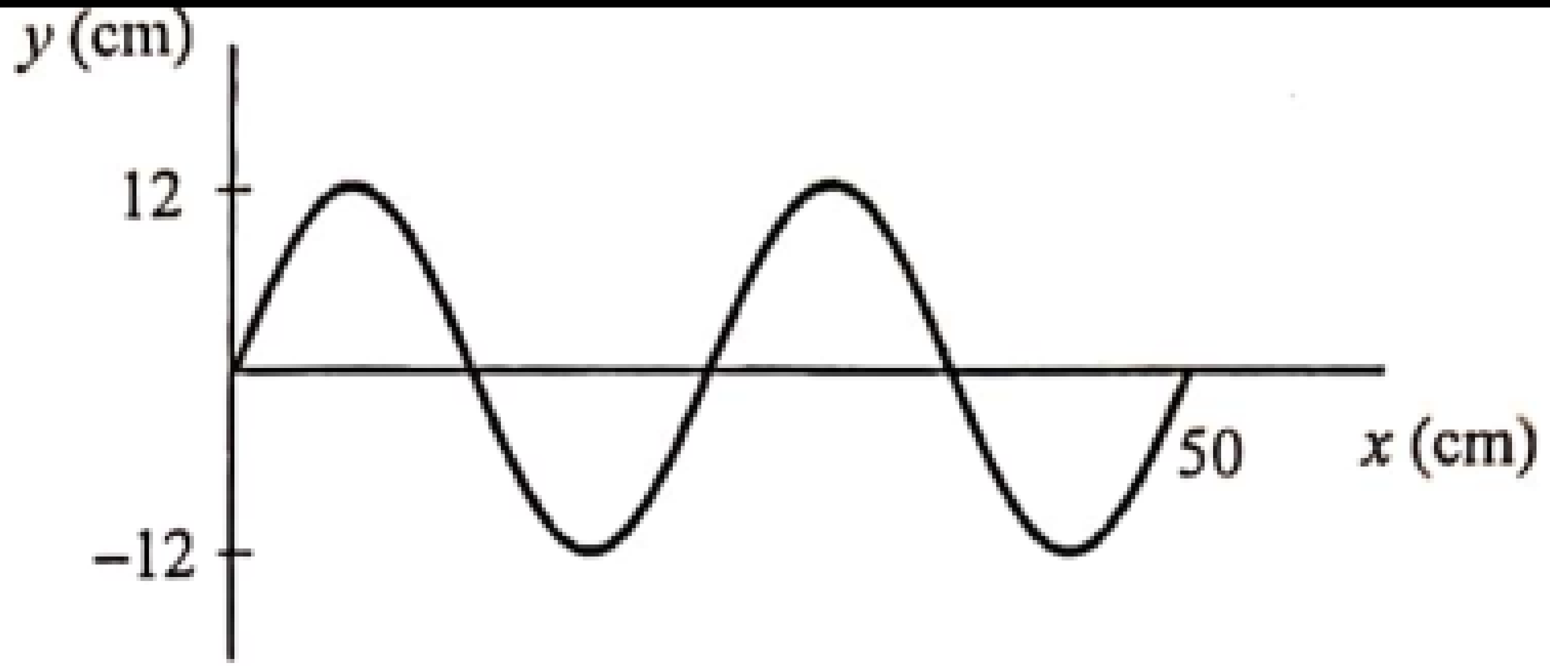


FIGURE 9

FIGURE 9 shows a graph of displacement y against distance x for a progressive wave propagating to the right in a string with mass 920 g, length 3 m and tension 15 N. Determine the progressive wave equation.

9 (a)

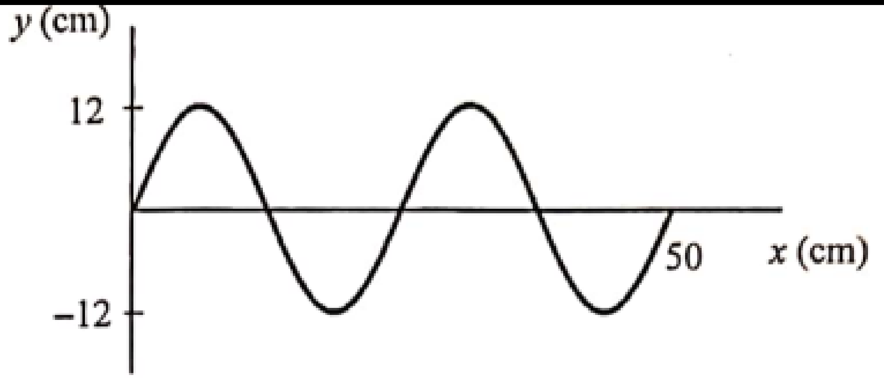


FIGURE 9

FIGURE 9 shows a graph of displacement y against distance x for a progressive wave propagating to the right in a string with mass 920 g, length 3 m and tension 15 N. Determine the progressive wave equation.

$y(x,t) = A\sin(\omega t \pm kx)$

to the right $\Rightarrow -kx$

$y(x,t) = A\sin(\omega t - kx)$

$A = 12$ cm from the graph

$y(x,t) = 12\sin(\omega t - kx)$

$k =$

ω until stretched string?

$V = f\lambda = \left(\frac{\omega}{2\pi}\right)\lambda$

$\omega = 2\pi f$

wave speed on string, $V = \sqrt{\frac{T}{\mu}}$ ← tension, ← mass density

$\sqrt{\frac{T}{\mu}} = \frac{\omega}{2\pi}\lambda$

$\omega = \frac{2\pi}{\lambda}\sqrt{\frac{T}{\mu}}$

$\omega = \frac{2\pi}{0.25}\sqrt{\frac{15}{\left(\frac{0.92}{3}\right)}}$

$\omega \simeq 175.77\ \text{rad s}^{-1}$

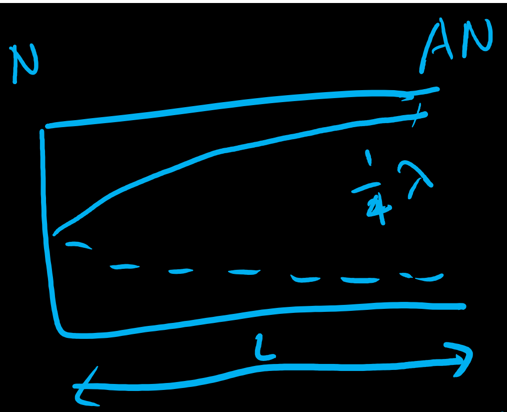
$y(x,t) = 12\sin(175.77t - 0.2513x)$

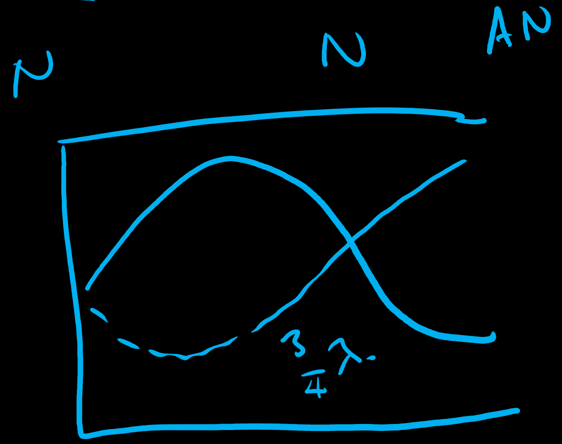
cm, cm^{-1}

$y(x,t) = 0.12\sin(175.77t - 8\pi x)$

m, m

(b) A 1.53 m closed pipe makes a humming sound at frequency 282 Hz when the wind blows across the open end. The speed of sound in air is 343 m s^{-1}. With the help of a diagram, determine the number of nodes in the standing wave.





$L = \frac{(2n+1)}{4}\lambda$

$\lambda(L)$

$v = f\lambda$

$f(\lambda) = 282 Hz.$

find n?

$\boxed{\text{3 nodes}}$

Doppler:

$V_t \neq 0$

(c) The frequency of whistle by a moving train and the frequency heard by a stationary observer are 520 Hz and 460 Hz respectively. If the speed of sound in the air is 343 m s^{-1}, calculate the speed of the train.

$V_o = 0$

$f' = 460\,Hz$

$f = 520\,Hz$

$V_{sound} = 343\,ms^{-1}$

V_t ?

$f' < f \Leftarrow$ train moving away from the observer!

$\boxed{V_t \approx 39.6\,ms^{-1}}$

Thank you!

17 November 2021

10 The diameter of a circular shoe $\boxed{\text{heel}}$ is 13 mm. If $\boxed{\text{both heels}}$ support 70% of the weight of a 54 kg woman, calculate the stress on both heels.

$d = 13\,mm$

$\delta = \dfrac{F}{A}$

$A(d) = \pi r^2$

$A(d) = \pi \left(\dfrac{d}{2}\right)^2$

$= \dfrac{\pi}{4} d^2$

$F = W$

$= 70\% \left[W_w\right]$

$F = 0.7(mg]$

$= 0.7(54)(9.81)$

$F = 370.82\,N$

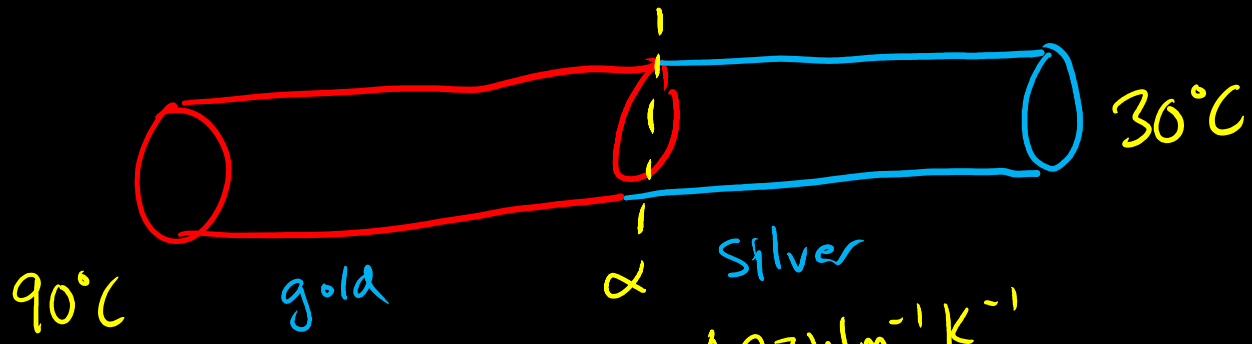
$A = \dfrac{\pi}{4}(13\times10^{-3})^2$

$A = 1.327(10^{-4}) \leftarrow$ area for single heel

$\delta \approx \dfrac{370.82N}{(1.327(10^{-4}))(2)} \Leftarrow$ stress on both heels

$\delta = 1.397(10^6)\,Nm^{2}$ #

11 (a) A gold rod is in contact with a silver rod. The gold end and the silver end of the compound rod is at 90 °C and 30 °C respectively. The silver rod has thermal conductivity 427 W m^{-1} K^{-1}, length 2.5 cm and cross-sectional area 7.85×10^{-5} m^2. If 341.3 J heat flows through the gold rod in 10 s, calculate the temperature at the contact surface.



427 W m^{-1} K^{-1}

$l = 2.5$ cm

$A = 7.85(10^{-5})$

$Q = 341.3$ J

$t = 10$ s

what is α ?

$$\frac{dQ}{dt} = -kA\frac{dT}{dx}$$

steady state

$$\left(\frac{dQ}{dt}\right)_{silver} = \left(\frac{dQ}{dt}\right)_{Gold}$$

$$\frac{-(427)(7.85(10^{-5}))(T_H - 30)}{L} = \frac{341.3}{10}$$

$T_H = 55.46$ °C

11 (b) The area of a metal plate changes from 120 m^2 to 120.059 m^2 when the temperature increases by 30 °C. Calculate the coefficient of linear expansion of the metal.

$\Delta A = A_f - A_i$ $\Rightarrow \beta = 2\alpha$

$= 120.059 - 120$

$= 0.059\ m^2$

$\Delta T = 30°C = 30K.$

$\Delta A(\Delta T, \beta) = \beta A_i \Delta T$

$\Delta A = 2\alpha A_i \Delta T.$

$\frac{0.059}{2 \times 120 \times 30} = \alpha.$

$\alpha = 8.194 \times 10^{-6}\ K^{-1}$

Thank you!

19 November 2021

Chapter 13 & 14

12 A sealed cylinder contains 1.2×10^{24} helium atoms at initial pressure 1.04×10^{5} Pa. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are 315 K and 1.6×10^{3} J respectively. The molar mass of helium is 4 g mol^{-1}. Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas.

$T_f > T_i$

N

P_i

T_f

ΔU

m_{molar}

12 A sealed cylinder contains 1.2×10^{24} helium atoms at initial pressure 1.04×10^{5} Pa. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are 315 K and 1.6×10^{3} J respectively. The molar mass of helium is 4 g mol^{-1}. Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas.

19/20

Date

12.

$N = 1.2 \times 10^{24}$ atoms

$P_i = 1.04 \times 10^{5}$ Pa

$PV = NkT$

$M_r = 4$ g mol^{-1}

$\Delta U = 1.6 \times 10^{1}$ J

$T_f = 315$ K

(a) ~~number of moles,~~ $n = \dfrac{\text{Number of atoms, } N}{\text{Avogadro's number, } N_A}$, $N_A = 6.02 \times 10^{23}$ mol^{-1}

$$n = \frac{1.2 \times 10^{24}}{6.02 \times 10^{23}}$$

$$n = 1.99 \text{ mol}$$

12 A sealed cylinder contains 1.2×10^{24} helium atoms at initial pressure 1.04×10^5 Pa. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are 315 K and 1.6×10^3 J respectively. The molar mass of helium is 4 g mol^{-1}. Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas.

mass of helium gas, m = number of moles, n × Molar mass, M_r

$$= n \times M_r$$

$$= 1.99 \times 4$$

$$= 7.96\ \text{g}$$

Based on the equipartition principle, for every DOF, $U = \frac{1}{2}kT$. Since the Helium is monoatomic, DOF = 3. The number of the helium $N = 1.2 \times 10^{24}$

Therefore, internal energy, $U = \frac{1}{2}fNkT$

change in internal energy, $\Delta U = \frac{1}{2}fNk(\Delta T)$, $k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$

$$\Delta U = \frac{1}{2}fNk(T_f - T_i)$$

$$1.6 \times 10^3 = \frac{1}{2}(3)(1.2)(1.38)(315 - T_i)(10^{24-23})$$

$$T_i = 250.59\ \text{K}$$

12 A sealed cylinder contains 1.2×10^{24} helium atoms at initial pressure 1.04×10^5 Pa. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are 315 K and 1.6×10^3 J respectively. The molar mass of helium is 4 g mol^{-1}. Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas.

Based on the ideal gas law,

$P_i V = NKT_i$

$V = \frac{NkT_i}{P_i}$

$V = \frac{(1.2)(1.38)(250.59)}{1.04}(10^{24-23-5})$

$V = 0.0399 \text{ m}^3$

Density of gas $= \frac{m}{V}$

$= \frac{7.96 \text{ g}}{0.0399 \text{ m}^3}$

$= 199.50 \text{ g m}^{-3}$

$= 0.1995 \text{ kg m}^{-3}$

12 A sealed cylinder contains 1.2×10^{24} helium atoms at initial pressure 1.04×10^5 Pa. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are 315 K and 1.6×10^3 J respectively. The molar mass of helium is 4 g mol^{-1}. Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas.

(b) Based on the ideal gas law

$pV = NKT$, $k = 1.38 \times 10^{-23}$ JK^{-1}

$P_f V = Nk T_f$

$P_f = \dfrac{Nk T_f}{V}$

$P_f = \dfrac{(1.2)(1.38)(315)}{0.0399}\left(10^{24-23}\right)$

$P_f = 130736.84$ Pa

12 A sealed cylinder contains 1.2×10^{24} helium atoms at initial pressure 1.(
The cylinder is heated until the final temperature and the change in the i
of the helium gas are 315 K and 1.6×10^3 J respectively. The molar mas
4 g mol^{-1}. Calculate the

(a) density of the helium gas.

(b) final pressure of the helium gas.

12.

$N = 1.2 \times 10^{24}$ atoms

$P_i = 1.04 \times 10^5$ Pa

$PV = NkT$

$M_r = 4 \text{ g mol}^{-1}$

$\Delta U = 1.6 \times 10^3 \text{ J}$

$T_f = 315 \text{ K}$

(a) number of moles, $n = \dfrac{\text{Number of atoms}, N}{\text{Avogadro's number}, N_A}$, $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$

$$n = \frac{1.2 \times 10^{24}}{6.02 \times 10^{23}}$$

$$n = 1.99 \text{ mol}$$

mass of helium gas, m = number of moles, n × Molar mass, M_r

$$= n \times M_r$$
$$= 1.99 \times 4$$
$$= 7.96 \text{ g}$$

Based on the (equipartition principle), for every DOF, $U = \frac{1}{2}kT$. Since the Helium is (monoatomic), DOF = 3. The number of the helium $N = 1.2 \times 10^{24}$

Therefore, Internal energy, $U = \frac{1}{2}fNkT$

change in internal energy, $\Delta U = \frac{1}{2}fNk(\Delta T)$, $k = 1.38 \times 10^{-23} \text{ J K}^{-1}$

$$\Delta U = \frac{1}{2}fNk(T_f - T_i)$$

$$1.6 \times 10^3 = \frac{1}{2}(3)(1.2)(1.38)(315 - T_i)(10^{24-23})$$

$$T_i = 250.59 \text{ K}$$

Based on the (ideal gas law),

$$PV = NkT_i$$

$$V = \frac{NkT_i}{P_i}$$

$$V = \frac{(1.2)(1.38)(250.59)}{1.04}(10^{24-23-5})$$

$$V = 0.0399 \text{ m}^3$$

Density of gas $= \dfrac{m}{V}$

$$= \frac{7.96 \text{ g}}{0.0399 \text{ m}^3}$$

$$= 199.50 \text{ g m}^{-3}$$

$$= 0.1995 \text{ kg m}^{-3}$$

13 A 0.8 m^3 container at 60 °C is filled with 0.6 mol ideal gas. The gas is isothermally compressed to a volume of 0.2 m^3. Then the gas expands isobarically to its initial volume. Calculate the total work done in the processes.

$$V_i \longrightarrow V_2 \longrightarrow V_i$$

$$T_i \longrightarrow T_i \longrightarrow T_f$$

$$n_i \longrightarrow n_i \longrightarrow n_i$$

$$W_i \qquad W_h$$

$$W_T = W_i + W_h$$

13 A 0.8 m^3 container at 60 °C is filled with 0.6 mol ideal gas. The gas is isothermally compressed to a volume of 0.2 m^3. Then the gas expands isobarically to its initial volume. Calculate the total work done in the processes.

13. $V = 0.8 m^3$

$T = 60°C = 333 K$

$n = 0.6$ mol

Isothermal process,

Ideal gas law,

$p = \frac{nRT}{V} \rightarrow -W = \int p\,dV$

$W = nRT \int_{V_1}^{V_2} \frac{1}{V}\,dv$

$W = nRT \ln\left(\frac{V_2}{V_1}\right)$, $R = 8.314\ J\,mol^{-1}\,K^{-1}$

$W = (0.6)(8.314)(\ln(\frac{0.2}{0.8}))(333)$

Onto? or by?

$W_1 = -2302.83\ J$

13 A 0.8 m^3 container at 60 °C is filled with 0.6 mol ideal gas. The gas is isothermally compressed to a volume of 0.2 m^3. Then the gas expands isobarically to its initial volume. Calculate the total work done in the processes.

Isobaric ~~al~~ process

$W = P(\Delta V)$, $P = \frac{nRT}{V}$

$W = \frac{nRT}{V}(V_f - V_i)$

$W = \frac{(0.6)(8.314)(333)}{0.2}(0.8 - 0.2)$

$W_2 = 4983.41 J$

Total work done in the processes $= W_2 + W_1$

$= 4983.41 - 2302.83$

$= 2680.58 J$

1st method

(1) $\Delta U = \Delta Q + \Delta W$ (a) or $\Delta U = \Delta Q - \Delta W$ (b)

Therll. onto. by.

$\Delta Q \to + \to$ heat into system

(2) Calculation

chose case (a)

$\Delta W < 0 \Rightarrow \Delta W = -1\,J.$

work done by the system is 1 J ✓

or

work done onto the system is −1 J ✓

(3) Refer to definition to understand your solution

2nd method

Joseph

An alternative strategy,

work by gas,

$V_f > V_i \Rightarrow$ expansion $\Rightarrow$ gas did work.

or

$V_f < V_i \Rightarrow$ compression $\Rightarrow$ work done on gas

1. Just calculate magnitude of ΔW

2. Check if $V_f > V_i$ or $V_i < V_f$

Monday

&

Tuesday

I will not be in.

Thanks!

24 November 2021

Past Year 17/18

Q4 and Q6

Q4b)

Chapter 7: Newtonian Gravity

(b) The International Space Station (ISS) is launched from the Earth and orbiting at an altitude of 350 km.

(i) Sketch and label the variation of the gravitational potential against distance from the surface of the Earth experienced by the ISS during the journey.

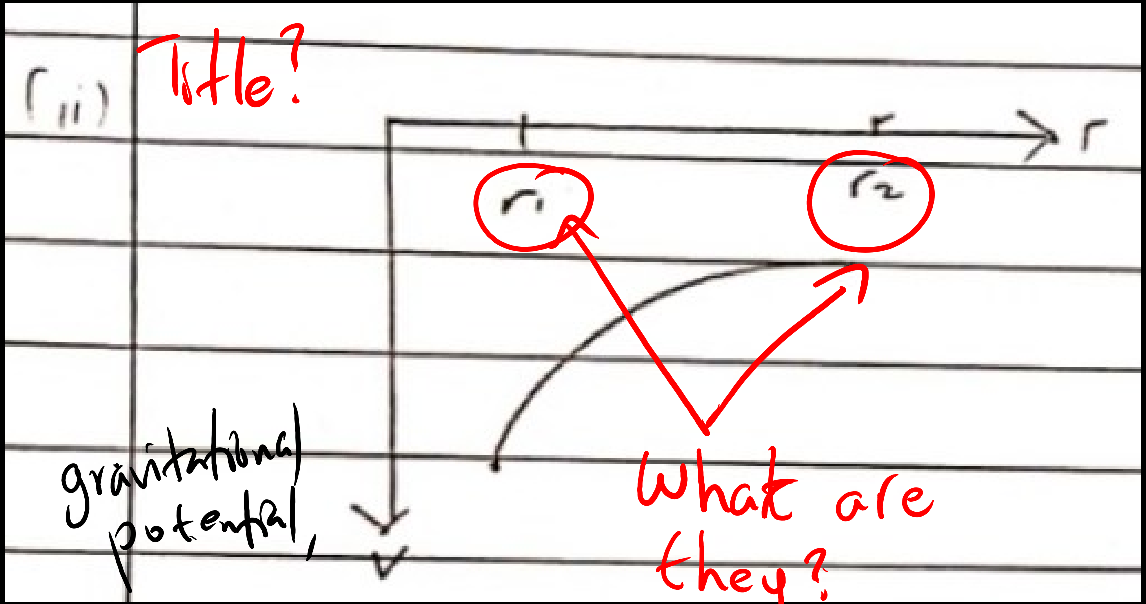
(ii) The ISS has a weight of 4.22×10^6 N when it is measured on the surface of the Earth. Given the mass and radius of the Earth is 5.98×10^{24} kg and 6.38×10^6 m respectively, calculate the weight of ISS when in its orbit.

Q4b) Isaucn.

(b) The International Space Station (ISS) is launched from the Earth and orbiting at an altitude of 350 $\boxed{\text{km}}$.

(i) Sketch and label the variation of the gravitational potential against distance from the surface of the Earth experienced by the ISS during the journey.

(ii) The ISS has a weight of 4.22×10^6 N when it is measured on the surface of the Earth. Given the mass and radius of the Earth is 5.98×10^{24} kg and 6.38×10^6 m respectively, calculate the weight of ISS when in its orbit.



$V \propto \frac{-1}{r}$

weight at surface

(ii) $W = \boxed{mg}$

$m = \frac{W}{g}$

$g = \frac{GM}{r^2}$

$= \frac{4.22 \times 10^6}{9.81}$

$= 4.30 \times 10^5$ kg

weight.

W in orbit = Gravitational force.

$F = G\frac{Mm}{r^2}$

$= \frac{(6.67\times10^{-11})(5.98\times10^{24})(4.30\times10^5)}{(6.38\times10^6 + \boxed{\cancel{350}})^2}$

350×10^3

$= 3.77 \times 10^6$ N

Q6b)

(b) In an engine, a 200 g piston oscillates in a simple harmonic motion with displacement varying according to $x(t) = 5 \cos 2t$ where x is in meter and t is in second.

(i) Write the expression for its vibrational velocity as a function of time, $v(t)$. taking derivative

(ii) Sketch the graph of velocity against time of the piston for the first complete cycle starting from $t = 0$.

(iii) Calculate the maximum acceleration of the system. $a = -\omega^2 x$

(iv) Calculate the total energy of the system. $E =$

Q6b)

(b) In an engine, a 200 g piston oscillates in a simple harmonic motion with displacement varying according to $x(t) = 5 \cos 2t$ where x is in meter and t is in second.

(i) Write the expression for its vibrational velocity as a function of time, $v(t)$.

(ii) Sketch the graph of velocity against time of the piston for the first complete cycle starting from $t = 0$.

(iii) Calculate the maximum acceleration of the system.

(iv) Calculate the total energy of the system.

5.(a) because there is a force, restoring force, is which causes simple harmonic motion to occur. This force is proportional to displacement from equilibrium & always directed towards equilibrium.

b(i) $v = \frac{dx}{dt}(5 \cos 2t)$ missing steps.

5×2

$= -10 \sin 2t$

Q6b)

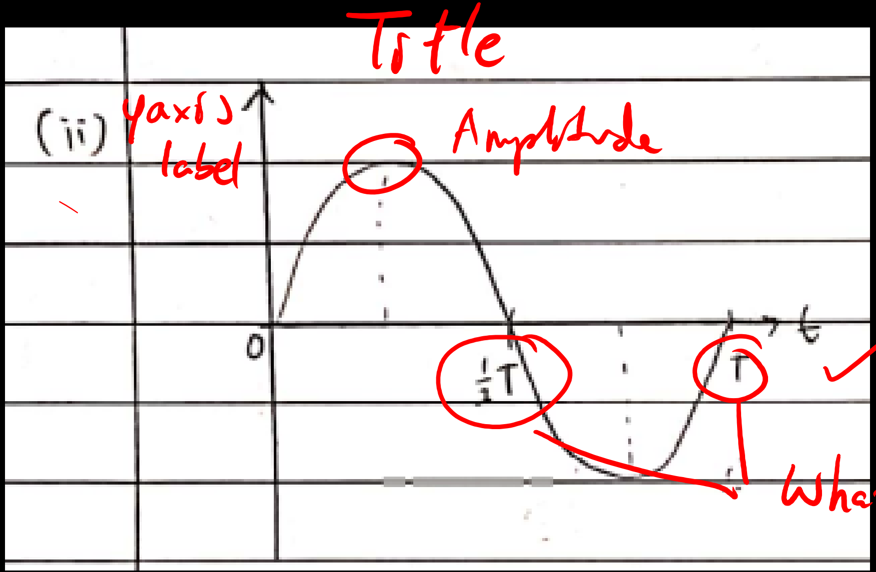
(b) In an engine, a 200 g piston oscillates in a simple harmonic motion with displacement varying according to $x(t) = 5\cos 2t$ where x is in meter and t is in second.

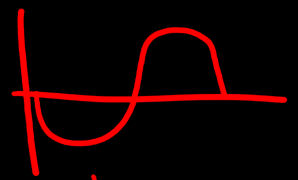
(i) Write the expression for its vibrational velocity as a function of time, $v(t)$.

(ii) Sketch the graph of velocity against time of the piston for the first complete cycle starting from $t = 0$.

(iii) Calculate the maximum acceleration of the system.

(iv) Calculate the total energy of the system.





(iii) $x = 5\cos 2t = A\cos\omega t$

$A = 5.0\ m$ $\quad \omega = 2\ rad/s$

maximum acceleration is when $t = 0$

$\ddot{x} = -\omega^2 A$

$= -(2.0)^2 \times \boxed{5.0}$

$= -20.0\ \cancel{rad/s}\ m s^{-1}$

$\ddot{x}$

$\frac{d^2x}{dt^2}$

a_{max}

Q6b)

(b) In an engine, a 200 g piston oscillates in a simple harmonic motion with displacement varying according to $x(t) = 5 \cos 2t$ where x is in meter and t is in second.

(i) Write the expression for its vibrational velocity as a function of time, $v(t)$.

(ii) Sketch the graph of velocity against time of the piston for the first complete cycle starting from $t = 0$.

(iii) Calculate the maximum acceleration of the system.

(iv) Calculate the total energy of the system.

$K(x)$

$U(x)$

(iv) $E = K + U$

$K?$

$U?$

$= \frac{1}{2} m\omega^2 A^2$

$= \frac{1}{2}(0.2)(2)^2(5)^2$

$= 10\ J$

Thank you!

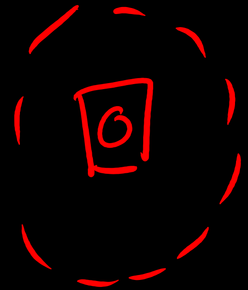
26 November 2021

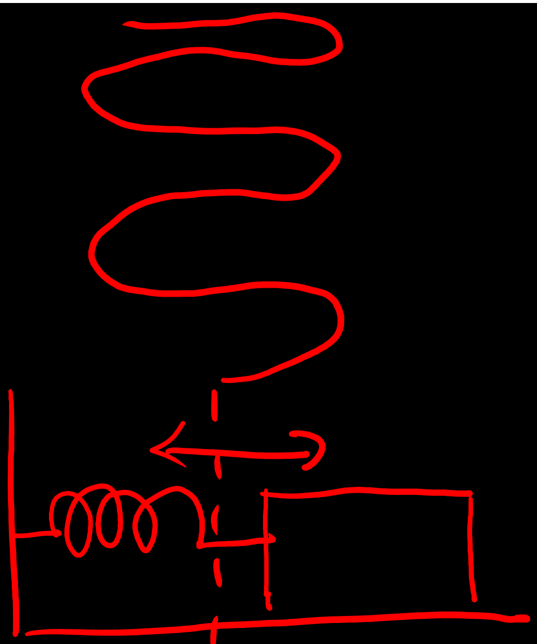
Question 7 & 8, PSPM 17/18

7 (a) (i) How does sound intensity change with distance from a point source?

(ii) In a longitudinal wave in a horizontal spring, the coils move back and forth in the direction of wave motion. If the coil speed is increased, does the wave propagation speed decrease, remain the same or increase? Explain your answer.

i) $I \propto \frac{1}{r^2}$





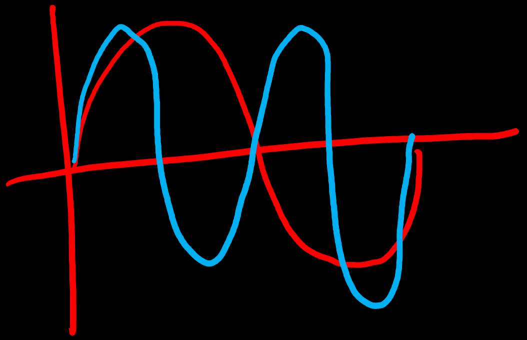
$\uparrow f;$

$v = f\lambda$

$f\uparrow \Rightarrow v\uparrow$ iff $\boxed{\lambda = \text{constant}}$

Is λ constant?

$\rightarrow$ $\lambda \neq$ constant



$\uparrow f, \downarrow \lambda$

v constant

(b) A progressive transverse wave traveling on a wire has amplitude of 0.2 mm and a frequency of 500 Hz with speed of 196 m s^{-1}.

(i) Write the displacement equation of the wave.

(ii) If the mass per unit length of the wire is 4.1 g m^{-1}. Calculate the tension of the wire.

7(b) $A = 0.2\ \text{mm} \ / \ 2 \times 10^{-4}\ \text{m}$

$f = 500\ \text{Hz}$

$v = 196\ \text{m s}^{-1}$

information

general equation

i $y(x,t) = A \sin(\omega t - kx)$

$\omega = 2\pi f$ $\quad v = f\lambda$

$= 2\pi(500)$ $\quad 196 = (500)\lambda$

$= 1000\pi$ unit $\quad \lambda = 0.392\ \text{m}$

information from question needed for GE.

$k = \frac{2\pi}{\lambda}$

$= \frac{2\pi}{0.392}$

$= 5.102\pi$

Calculation of GE constants

unit.

$\therefore y(x,t) = \boxed{2 \times 10^{-4}} \sin(\boxed{1000\pi} t - \boxed{5.102\pi} x)$

A m

ω rad s^{-1}

k m^{-1}

(b) A progressive transverse wave traveling on a wire has amplitude of 0.2 mm and a frequency of 500 Hz with speed of 196 m s^{-1}.

(i) Write the displacement equation of the wave.

(ii) If the mass per unit length of the wire is 4.1 g m^{-1}. Calculate the tension of the wire.

ii. $\mu = 4.1\ g\ m^{-1}$ / $4.1 \times 10^{-3}\ kg\ m^{-1}$

$v = \sqrt{\frac{T}{\mu}}$ } wave speed travelling in stretched wire

$v^2 = \frac{T}{\mu}$

$T = v^2 \mu$

$= (196)^2 (4.1 \times 10^{-3})$

$= 157.5056\ N$

Betul calculation according to Dell.

(c) A submarine that travels in the water at a speed of 8 m s^{-1} and emits a sonar wave of frequency 1400 Hz is approaching another stationary submarine. Given the speed of sound in water is 1530 m s^{-1}, calculate the apparent frequency as detected by an observer in the stationary submarine.

7(c) $v_s = 8 \ ms^{-1}$

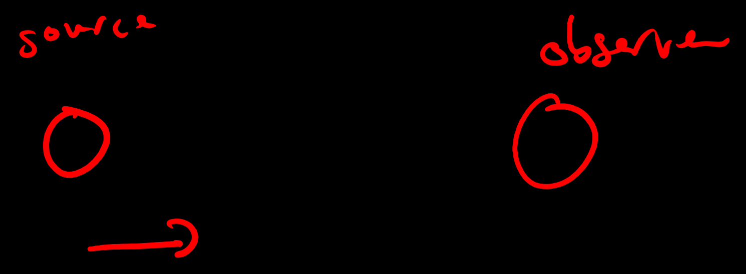
$f_s = 1400 \ Hz$

$v = 1530 \ ms^{-1}$

$$f_a = f_s \left(\frac{v \pm v_o}{v - v_s} \right)$$

$$= 1400 \left(\frac{1530 + 0}{1530 - 8} \right)$$

$$= 1407.36 \ Hz$$



(d) A 20 cm cylindrical brass rod with diameter 6 cm is held vertically on its one circular flat end. A load of 5 kg is placed on its upper end. Given the Young's modulus of brass is 9.1×10^{10} N m^{-2}, calculate the strain energy of the rod.

7(d) diameter = 6 cm

$l = 20$ cm

$m = 5$ kg

$Y = 9.1 \times 10^{10}$ N m^{-2}

$\sigma = \frac{F}{A}$

$\epsilon = \frac{\Delta L}{L}$

$Y = \frac{\sigma}{\epsilon}$

$$\frac{U}{V} = \frac{1}{2}\varepsilon\sigma.$$

$$U = \frac{1}{2}(Al)\varepsilon\sigma.$$

$$\simeq 9.35(10^{-7})\text{ J}.$$

8 (a) (i) Define heat.

(ii)

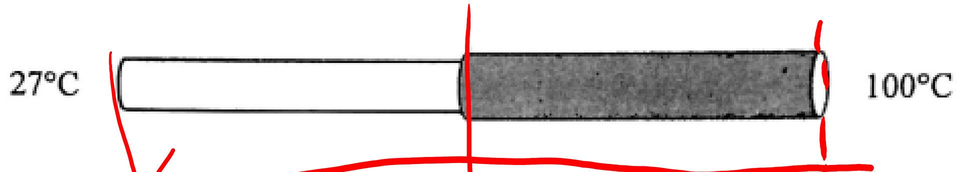


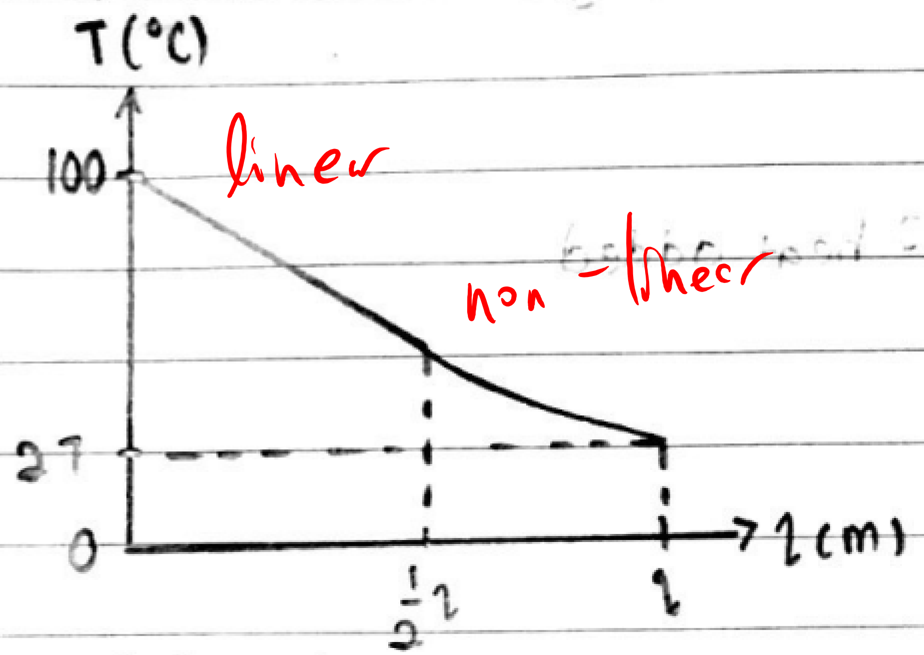
FIGURE 8.1
RAJAH **8.1**

FIGURE 8.1 shows a rod with both ends at different temperatures. The right half of the rod is insulated while the left half is not insulated. Sketch the graph of temperature against distance of the rod.

area area

i. Heat is energy transit from high temperature object to lower temperature object.

ii.



(b) (i) A 5×10^{-3} m^3 tank contains nitrogen at temperature 27°C and pressure 1.2 atm. The gas pressure increases to 2.5 atm when the tank is heated. Given the molar mass of nitrogen is 28 g mol^{-1}, calculate the change in the rms speed of the nitrogen molecules.

(ii) At the same temperature, which gas has a greater energy per mole: a diatomic gas or a monoatomic gas? Explain your answer.

(b) i. $V = 5 \times 10^{-3}\ m^3$ $T = 27°C = 300\ K$ $P_1 = 1.2\ atm \times 101325 = 1.22 \times 10^5\ Pa$

When heated, $P_2 = 2.5\ atm \times 101325 = 2.53 \times 10^5\ Pa$

$M_r = 28\ g\,mol^{-1} = 2.8 \times 10^{-2}\ kg\,mol^{-1}$

$$\left.\begin{aligned} V_{1rms} &= \sqrt{\frac{3RT}{M_r}} \\ &= \sqrt{\frac{3(8.31)(300)}{2.8 \times 10^{-2}}} \\ &= 516.82\ ms^{-1} \end{aligned}\right\} V_{rms} \text{ when } T = 27°C$$

Ideal gas law, $pV = nRT$

V, n and R is constant, Thus,

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$T_2 = \frac{P_2 T_1}{P_1} = \frac{(2.53 \times 10^5)(300)}{(1.22 \times 10^5)} = 622.13\ K$$

$$V_{2rms} = \sqrt{\frac{3(8.31)(622.13)}{2.8 \times 10^{-2}}} = 744.26\ ms^{-1} \Big\} V_{rms} \text{ when } T + \Delta T = T_f$$

$$\Delta V_{rms} = V_{2rms} - V_{1rms} = 744.26 - 516.82$$

$$\boxed{\Delta V_{rms} = 227.44\ ms^{-1}}$$

take the diff.

$\Delta P \neq 0$; $\Delta T \neq 0 \Rightarrow \Delta U \neq 0$

$\Delta I \Rightarrow$

(b) (i) A 5×10^{-3} m^3 tank contains nitrogen at temperature 27°C and pressure 1.2 atm. The gas pressure increases to 2.5 atm when the tank is heated. Given the molar mass of nitrogen is 28 g mol^{-1}, calculate the change in the rms speed of the nitrogen molecules.

(ii) At the same temperature, which gas has a greater energy per mole: a diatomic gas or a monoatomic gas? Explain your answer.

Subject

ii Diatomic gas. Diatomic gas has 5 degree of freedom while monoatomic gas only has 3 degree of freedom. According to the principle of equipartition of energy, for 1 mole gas, $E = \frac{f}{2}kT$. Based on the equation, Internal energy, $U = \frac{f}{2}RT$; Diatomic gas will has greater U than monoatomic gas.

(c)

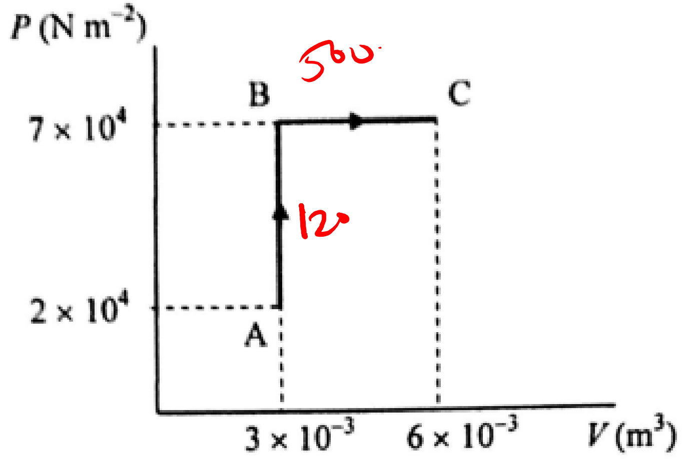


FIGURE 8.2
***RAJAH* 8.2**

FIGURE 8.2 shows a series of thermodynamic processes ABC. During the process AB and process BC, 120 J of heat and 500 J of heat are added respectively. Calculate the change in the internal energy in the process ABC.

(c) AB : 120J heat added ; BC : 500J heat added Infor.

AB : Isochoric process , $\Delta W = 0$
BC : Isobaric process , $\Delta P = 0$ What process are involved?

First law of thermodynamics : $\Delta U = \Delta Q - W$ ← Work done onto the system

Change in internal energy

heat transfer/absorb

AB : $\Delta U = \Delta Q - W$ $= 0$
$\Delta U = \Delta Q$
$= 120J$

BC : $\Delta U = \Delta Q - W$
$= 500J - ((7 \times 10^4)(6 \times 10^{-3} - 3 \times 10^{-3}))$
$= 500J - 210J$
$= 290J$

Total change in internal energy = 290J + 120J

$\boxed{\Delta U_{ABC} = 410J}$

Thank you!

PHYSICS UNIT
KOLEJ MATRIKULASI SARAWAK

SMART PHYSICS WORKSHOP
27 NOVEMBER 2021

This question paper contain 30 objective questions.
Answer all questions.

1 The dimensions of gravitational constant G is

A $L M T$ C $L^3 M^{-1} T^{-2}$

B $L^3 M T^2$ D $L^3 T^{-2}$

2 A ball is thrown horizontally at $20.0 ms^{-1}$ from the roof of building. If the ball hits the ground after $4.0 s$, the height of the building is

A 5.0 m C 78.5 m

B 19.6 m D 157.0 m

3 A driver travelling at 100 *km h*$^{-1}$ on a straight road suddenly sees a cat 30 *m* ahead and immediately applies the brake. His braking deceleration is 6 *ms*$^{-2}$. Calculate the minimum time that he should apply the brake so that he does not hit the cat.

A 8.01 s C 1.25 s

B 3.67 s D 5.88 s

①

$$a_g = \frac{GM}{r^2}$$

$$G = \frac{a_g r^2}{M}$$

$$\frac{LT^{-2}\ L^2}{M}$$

$$L^3 T^{-2} M^{-1}$$

②

$$\theta = 0^\circ$$

$$u_y = 0 = u \sin\theta$$

$$S_y = \cancel{\boxed{u_y}} - \frac{1}{2} g t^2$$

$$S_y = -\frac{1}{2}(9.81)(4)^2$$

$$S_y = 78.48 m$$

③

$$u = \frac{100 km}{1 hour} = \frac{100 \times 10^3 m}{60 \text{ minutes}}$$

$$u = \frac{100 \times 10^3}{60 \times 60} ms^{-1}$$

$$u = 27.8 ms^{-1}$$

$$S = 30 m \ ; \ a = -6 ms^{-2}$$

$$S = ut + \frac{1}{2} a t^2$$

$$30 = (27.8)(t) + \frac{1}{2}(-6)t^2$$

$$t = 1.25 s.$$

C

4 A ball is projected from the ground with velocity of 10 ms^{-1} at an angle of 30° with the horizontal. The range of the projectile is

A 8.82 m C 6.45 m
B 5.10 m D 7.45 m

5 A tennis ball with a mass of 57 g and velocity of 20 ms^{-1} is struck by a racket. The ball's velocity changes to 40 ms^{-1} in the opposite direction. What is the average force acting on the ball if its time of contact with the racket is 50.0 ms ?

A 11.4 N C 34.2 N
B 22.8 N D 68.4 N

6 A mass of 4 kg moving at 3 ms^{-1} collide with a mass of 6 kg moving at 2 ms^{-1} in the opposite direction and they stick together. The combined mass has velocity of

A 5.6 ms^{-1} C 4.8 ms^{-1}
B 2.4 ms^{-1} D Zero

(6)

$3 ms^{-1}$ $2 ms^{-1}$

$(4) \longrightarrow$ $\longleftarrow (6)$

$\longrightarrow +$

$\Delta p = 0$

$P_i = P_f$

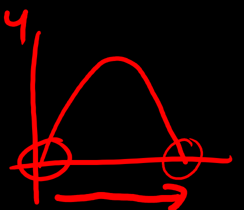
$m_1 u_1 + m_2 u_2 = (m_1 + m_2) V$

$(4)(+3) + 6(-2) = (4+6) V$

$V = \frac{4(3) - 6(2)}{10} = \frac{0}{10} = 0 ms^{-1}$

(4) $u = 10 ms^{-1}$

$\theta = 30°$



$S_y = 0 = u_y t + \frac{1}{2} a_y t^2$

$0 = (10 \sin 30) t - \frac{1}{2}(9.81) t^2$

$t = \{0, 1.019 s\}$

$S_x = u_x t = (10 \cos 30)(1.019)$
$= 8.825 m$

(5) $u = 20 ms^{-1}$

$v = -40 ms^{-1}$

$m = 0.057 kg$

$t = 50(10^{-3}) s.$

$F = \frac{\Delta P}{\Delta t} = m \frac{\Delta v}{t}$

$F = 0.057 \times \left(\frac{-40 - 20}{50(10^{-3}) s} \right) = -68.4 N$

6 A mass of 4 kg moving at 3 ms^{-1} collide with a mass of 6 *kg* moving at 2 ms^{-1} in the opposite direction and they stick together. The combined mass has velocity of

A 5.6 ms^{-1} C 4.8 ms^{-1}

B 2.4 ms^{-1} D Zero

7 A box of weight W is hung by two strings as shown in FIGURE 1. If the tension on each string is 80 *N*, what is the mass of the box? (A)

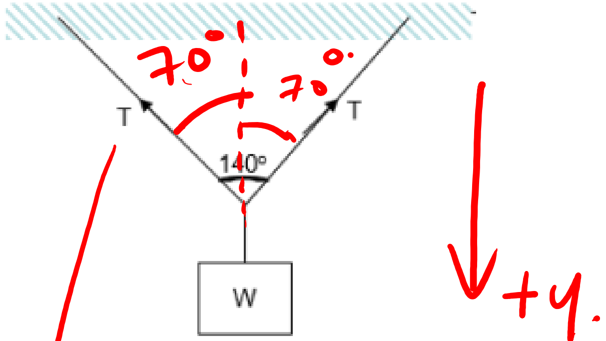


FIGURE 1

A 5.6 kg C 10.2 kg

B 7.7 kg D 17.7 kg

$\sum F_y = 0 = W - T\cos 70 - T\cos 70$

$mg = 2T\cos 70$

$m = \dfrac{2(80)\cos 70}{9.81} \approx 5.6\,kg$

A

8 A 3.0 kg block slides down a rough inclined plane of angle 20° with the horizontal at a constant speed u = 1.5 ms^{-1}. Calculate the coefficient of frictional force.

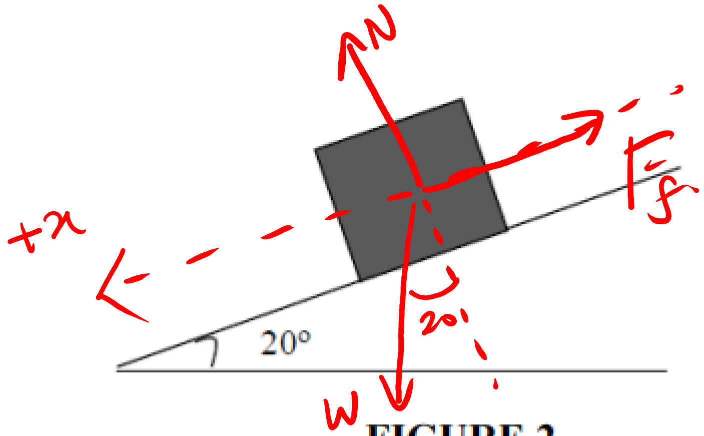


FIGURE 2

A 0.36
B 0.20
C 2.3
D 0.53

$W \sin 20 = \mu N$

$\mu = \dfrac{W \sin 20}{27.66}$

$= \dfrac{3(9.81)(\sin 20)}{27.66}$

$\mu \approx 0.36$

A

$a = 0$

$\Delta V = 0$

$\sum F_x = W_x - F_f = 0$

$W_x = F_f$

$\sum F_y = W_y - N = 0$

$N = W_y$

$= W \cos 20$

$= 3(9.81) \cos 20$

$N \approx 27.66 N$

9 A 1.0 kg block is pulled by a 10.0 N force as shown in **FIGURE 3.** The coefficient of friction between the blockand surface is 0.3. If the block is displaced 5.0 m horizontally, the net work done on the block is

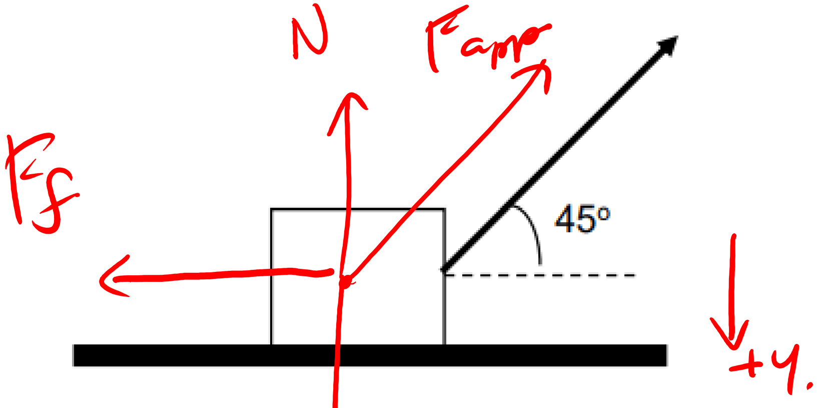


FIGURE 3

A 2.9 J

B 6.3 J

C 26.3 J

D 31.3 J

$W = F \cdot s$

$s = 5m$

$\sum F_x = F_{app} \cos 45 - F_f$

$F_f = \mu(N)$

$\sum F_y = 0 = W - N - F_{app} \sin 45$

$W = N + F_{app} \sin 45$

$N = W - F_{app} \sin 45$

$N = 9.81(1) - 10 \sin 45$

$N \approx 2.74N$

$F_f = 0.3(2.74$

$F_f \approx 0.82N$

$W_x = (\sum F_x)(s)$

$W_x = (10 \cos 45 - 0.82)(5)$

$W_x = 31.3 J.$

10 A spring with a spring constant of $5\times10^5\, Nm^{-1}$ is compressed by 0.01m. What is the potential energy of the spring?

A 5 J C 50 J

B 25 J D 70 J

11 A block initially at rest slides down a frictionless inclined plane from a height *h*. It reaches the bottom of the inclined plan with a final speed *v*. To attain a final speed *4v*, it should fall from a height

A 5 h C 16 h

B 10 h D 26 h

12 A van of mass M kg negotiates a circular road whose radius is 100m. If the frictional force between its tyres and the road is 0.5 times its weight. What is the maximum speed at which the van can safely negotiate the curve without skidding?

A 11.80 m s^{-1} C 20.20 m s^{-1}

B 16.00 m s^{-1} D 22.15 m s^{-1}

10 $5(10^5)\, Nm^{-1} = k$

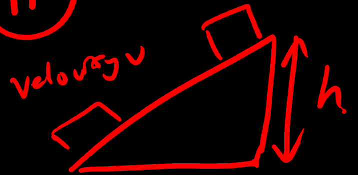
$\Delta l = 0.01\,m$

$U = \frac{1}{2}kx^2 = \frac{1}{2}(5)(10^5)(0.01)^2$

$x = \Delta l$

$U \simeq 25J$

11



$\Delta E = 0$

$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$

$V = \sqrt{gh}$

$h = \frac{v^2}{g}$

$h' = \frac{(4v)^2}{g}$

$h' = 16\frac{v^2}{g}$

$h' = 16h$

12

$F_c = \frac{mv^2}{r} = f$

$f = 0.5(mg)$

$\frac{\cancel{m}v^2}{r} = 0.5\cancel{m}g$

$V^2 = gr(0.5)$

$V = \sqrt{0.5gr}$

$V = \sqrt{0.5(9.81)(100)}$

$V \simeq 22.15\, ms^{-1}$

13 If the acceleration due to gravity becomes 4 times its original value, then escape speed

A remains same
B 2 times of original value
C becomes halved
D 4 times of original value

14 The mass of the moon is 7.34 x 10^{22} kg and the radius is 1.76 x 10^{6} m. The value of gravitation acceleration will be

A 2.78 ms^{-2}
B 1.58 ms^{-2}
C 7.58 ms^{-2}
D 5.77 ms^{-2}

15 The position of simple harmonic oscilltor is given by $x(t) = 0.20\, cos\, \frac{\pi}{3} t$ where x is in meter, t in seconds. What is the period of the oscillator?

A 0.17 s
B 0.67 s
C 6.0 s
D 3.0 s

13

$V_{esc}(a_g)$

$V_{esc} = \sqrt{2 a_g R}$

$V'_{esc} = \sqrt{2(4a_g)(R}$

$V'_{esc} = 2\underbrace{\sqrt{2 a_g R}}_{V_{esc}}$

$\boxed{V'_{esc} = 2 V_{esc}}$

14

$a_g(m, r) = \frac{Gm}{r^2}$

$a_g = \frac{(6.67)(7.34)}{(1.76)^2}\left(10^{-11+22-6-6}\right)$

$a_g \simeq 1.58 ms^{-2}$

15

$x(t) = 0.2 \cos \frac{\pi}{3} t$

m

s

$\omega = \frac{\pi}{3}$ rad s^{-1}

$T(\omega) = \frac{2\pi}{\omega} = \frac{2\pi}{\left(\frac{\pi}{3}\right)}$

$T = 2\cancel{\pi}\left(\frac{3}{\cancel{\pi}}\right) = 6 s$ //

16 An object performs a SHM according to equation $x = 4.0 \cos\left(\pi t + \frac{\pi}{4}\right)$ where x is in meters, t is in seconds. Find its accelerationa time t = 1.0 s.

A 16.3 m s^{-2} C 27.9 m s^{-2}

B 21.3 m s^{-2} D 39.4 m s^{-2}

17 An particle move in simple harmonic motion with equation $x = 3.4 \sin\left(\frac{2\pi}{3} t\right)$ where x is in meters, t is in seconds. Find its velocity when x = 89.0 cm.

A 12.23 m s^{-1} C 9.43 m s^{-1}

B 6.87 m s^{-1} D 26.3 m s^{-1}

18 The period of a simple pendulum is 3.0 s. What is the length of the simple pendulum?

A 2.24 m   C 3.68 m

B 3.27 m   D 8.19 m

16

$x = 4 \cos\left(\pi t + \frac{\pi}{4}\right)$

m   s

SHM: $a = -\omega^2 x$

$a = -\pi^2 \left[4 \cos\left(\pi t + \frac{\pi}{4}\right)\right]$

$a = -4\pi^2 \cos\left(\pi(1) + \frac{\pi}{4}\right) \simeq 27.9$ ms^{-2}

17

$v(x) = \pm\omega\sqrt{A^2 - x^2}$

$x = 3.4 \sin\left(\frac{2}{3}\pi t\right)$

$\omega = \frac{2}{3}\pi$ rad s^{-1}

$A = 3.4$ m

$V = \pm\left(\frac{2}{3}\pi\right)\sqrt{3.4^2 - 0.89^2}$

$V \simeq 6.87$ ms^{-1}

18 $T = 3$ s

$T(l)$

$\left.\begin{array}{l}\omega^2 = \frac{g}{l} \\ T = \frac{2\pi}{\omega}\end{array}\right\} T = 2\pi\sqrt{\frac{l}{g}}$

$l = \left(\frac{T}{2\pi}\right)^2 g$

$l = \left(\frac{3}{2\pi}\right)^2 (9.81)$

$l \simeq 2.24$ m

19 A progressive wave is represented by the equation:

$$y = 2\sin 2\pi(5t + 2x)$$

negative

where x and y are in meter and t in second. Determine the wave speed **and** direction of wave propagation.

A. $0.5\ \mathrm{m\ s^{-1}}$ in the positive x-direction
B. $2.5\ \mathrm{m\ s^{-1}}$ in the positive x-direction
C. $0.5\ \mathrm{m\ s^{-1}}$ in the negative x-direction
D. $2.5\ \mathrm{m\ s^{-1}}$ in the negative x-direction

20 The equation of a progressive wave is given by

$$y = 4\sin(6t + x)$$

Where y and x in centimeter and t in second. What is maximum speed of the vibrating particles?

A. $24\ \mathrm{cm\ s^{-1}}$ B. $25\ \mathrm{cm\ s^{-1}}$ C. $26\ \mathrm{cm\ s^{-1}}$ D. $27\ \mathrm{cm\ s^{-1}}$

20 $y = 4\sin(6t + x)$

$\frac{dy}{dt} = 4(6)\cos(6t + x)$ 1

$V_{max} = 4(6) = 24\ \mathrm{cm\ s^{-1}}$

A

19 $A = 2\mathrm{m}$

$\omega = 2\pi(5) = 10\pi\ \mathrm{rad\,s^{-1}}$

$k = 2\pi(2) = 4\pi\ \mathrm{m^{-1}}$

$V = f\lambda$

$V(\omega, k)$

$\omega(f) = 2\pi f$

$f = \frac{\omega}{2\pi}$

$k(\lambda) = \frac{2\pi}{\lambda}$

$\lambda = \frac{2\pi}{k}$

$V = f\lambda$

$= \frac{\omega}{\cancel{2\pi}}\left(\frac{\cancel{2\pi}}{k}\right)$

$= \frac{\omega}{k}$

$= \frac{10\cancel{\pi}}{4\cancel{\pi}} = 2.5\ \mathrm{m\,s^{-1}}$

21 A progressive wave is represented by

$$y = 4.5 \sin \frac{\pi}{3}(66t - x)$$

Where y and x are measured in centimeter and t in second. Calculate the frequency **and** the wavelength of the wave.

A. ~~66 Hz~~, 67 cm B. ~~66 Hz~~, 4.5 cm C. 11 Hz, 4.5 cm D. 11 Hz, 6.0 cm

22 A string is stretched between two points of 50 cm apart. The speed is transvers wave in the string is 30 m s^{-1}. Determine the fundamental frequency of the stationary wave in the string.

A. 15 Hz B. 30 Hz C. 45 Hz D. 60 Hz

$\lambda = 2l = 2(0.5)$

$\lambda = 1\ \text{m}$

$v(\lambda) = f\lambda$

$30 = f(1)$

$f = 30\ \text{Hz}$

21

$\omega(f) = 2\pi f$

$\frac{\pi}{3}(66) = 2\pi f$

$\frac{22\pi}{2\pi} = f$

$f = 11\ \text{Hz}$

$k(\lambda) = \frac{2\pi}{\lambda}$

$\lambda = \frac{2\pi}{k} = 2\pi\left(\frac{3}{\pi}\right)$

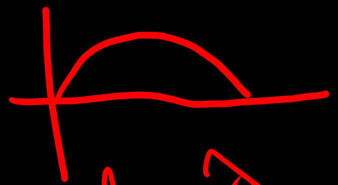
$\lambda = 6\ \text{cm}$

22

$l = 50\ \text{cm}$

$= 0.5\ \text{m}$

$v = 30\ \text{m s}^{-1}$



$l = \frac{\lambda}{2}$

$V_s = 0$

23 A stationary source emits a sound wave of frequency f. If an observer travels towards the source at half the speed of sound, the observed frequency is

A. $\dfrac{f}{2}$ B. f C. $\dfrac{3f}{2}$ D. $2f$

24

FIGURE 4

The graph above shows stress versus strain curve of a material. What is the Young's modulus of the material?

A. 200 Pa B. 150 Pa C. 100 Pa D. 50 Pa

24

$$Y = \frac{\sigma}{\varepsilon} = \frac{3}{30(10^{-3})}$$

$$Y = 100 \text{ Pa.}$$

23

$$f' = \left(\frac{V \pm V_o}{V \mp \cancel{V_s}\,0}\right) f \qquad V_o = \tfrac{1}{2}V$$

$$f' = \left(\frac{V + V_o}{V}\right) f \qquad f' = \left(\frac{\cancel{V} + \frac{1}{2}\cancel{V}}{\cancel{V}}\right) f$$

$$f' = 1.5\, f = \tfrac{3}{2} f$$

25 A 2.5 cm copper rod has a radius of 300 mm. One end of the copper is placed in a fire at 95°C and the other end is kept at 45°C. Given the coefficient of thermal conductivity of copper is 385 $Wm^{-1}K^{-1}$, what is the amount of heat conducted from hot end of the rod to the cold end in 10 s?

A 2.17×10^6 J
B 3.51×10^6 J
C 4.43×10^6 J
D 6.52×10^6 J

26 A 45.0 liter steel container is full of oil at a temperature of 30 °C. If the temperature is increased to 50 °C, how much will the oil spill
(Coefficient of linear expansion of steel is $1.2 \times 10^{-5}\ K^{-1}$)
(Coefficient of volume expansion of oil is $4.5 \times 10^{-4}\ K^{-1}$)

A $12.43 \times 10^{-4}\ m^3$
B $0.97 \times 10^{-4}\ m^3$
C $7.55 \times 10^{-4}\ m^3$
D $3.73 \times 10^{-4}\ m^3$

27 A polyatomic gas at 27 °C possesses both translational and rotational motions. Determine the translational kinetic energy of the polyatomic molecule.

A. 6.21×10^{-20} J
B. 1.24×10^{-21} J
C. 1.24×10^{-20} J
D. 6.21×10^{-21} J

26 $\Delta V = \gamma V_0 \Delta T$

$\gamma_{steel} = 3\alpha = 3.6 \times 10^{-5}\ K^{-1}$

$\Delta V_s = (3.6)(10^{-5})(45 \times 10^{-3})(20)$

$\simeq 3.24(10^{-5})\ m^3$

$\Delta V_{oil} = (4.5)(10^{-4})(45)(10^{-3})(20)$

$\Delta V_{oil} \simeq 4.05(10^{-4})\ m^3$

25 $\frac{dQ}{dt} = -kA\frac{dT}{dx}$

$Q = -kA\frac{dT}{x}dt$

$Q = -(385)(\pi)(0.3^2)\left(\frac{95-45}{0.025}\right)(10)$

$Q \simeq 2.17(10^6)$ J.

A

$\Delta V_{s.o} = \Delta V_{oil} - \Delta V_{steel}$

$= (40.5 - 3.24)(10^{-5})$

$\simeq 37.3 \times 10^{-5}\ m^3$

25 A 2.5 cm copper rod has a radius of 300 mm. One end of the copper is placed in a fire at 95°C and the other end is kept at 45°C. Given the coefficient of thermal conductivity of copper is 385 $Wm^{-1}K^{-1}$, what is the amount of heat conducted from hot end of the rod to the cold end in 10 s?

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D $3.73 \times 10^{-4}\ m^3$

27 A polyatomic gas at 27 °C possesses both translational and rotational motions. Determine the translational kinetic energy of the polyatomic molecule.

A. 6.21×10^{-20} J
C. 1.24×10^{-20} J
B. 1.24×10^{-21} J
D. 6.21×10^{-21} J

$E_{Tk} = \frac{f}{2} k_B T = \frac{3}{2}(1.38 \times 10^{-23})(27+273)$

$E_{Tk} = 6.21 \times 10^{-21}$ J

28 If the temperature of an ideal gas decreases from 200 K to 100 K, what is the ratio of its final internal energy to its initial internal energy?

A. $\frac{1}{2}$ B. $\frac{1}{4}$ C. 6 D. 4

29 A system absorbs 7000 J of heat and at the same time 3000 J of work is $\boxed{\text{done on it.}}$ Calculate the change in internal energy of the gas in the system.

A. 4000 J B. −4000 J C. 10000 J D. −10000 J

28

$U = \frac{f}{2} k_B T N$

$U_{old} = \frac{f}{2} k_B (200k) N$ — ①

$U_{new} = \frac{f}{2} k_B (100k) N$ — ②

$\frac{②}{①}$

$\frac{U_{new}}{U_{old}} = \frac{\cancel{\frac{f}{2}} \cancel{k_B} (100k) \cancel{N}}{\cancel{\frac{f}{2}} \cancel{k_B} (200k) \cancel{N}} = \frac{100}{200}$

$= \frac{1}{2}$ //

29

~~ΔW~~

$\Delta U = \Delta Q + \Delta W$

onto.

$\Delta U = 7000J + 3000$

$\Delta U = 10000J.$

30

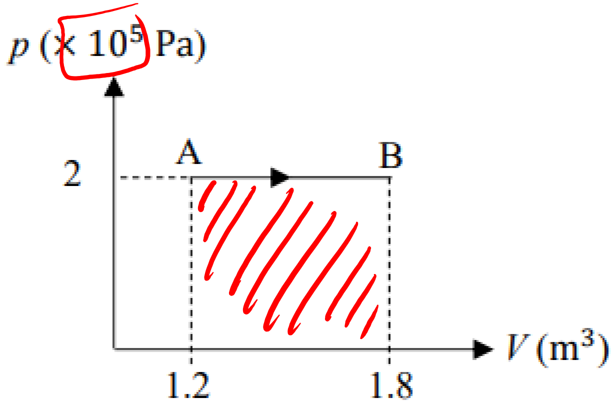


FIGURE 5

An ideal gas undergoes a process AB as shown in p-V graph above. Determine the workdone by the gas.

A. 0.7×10^5 J B. 0.9×10^5 J C. 1.1×10^5 J D. 1.2×10^5 J

30

$\Delta p = 0 \Rightarrow$ isobaric process

area under graph represent Work done

$$W = (1.8 - 1.2)(2 \times 10^5)$$

$$W = 1.2 \times 10^5 \text{ J}.$$

Thank you!

29 November 2021

1. Given the equation **momentum**= k ×**density**, what is dimension for k ?

A. ML^2T^{-1}

B. ML^2T^{-2}

C. L^4T^{-1}

D. L^2T^{-1}

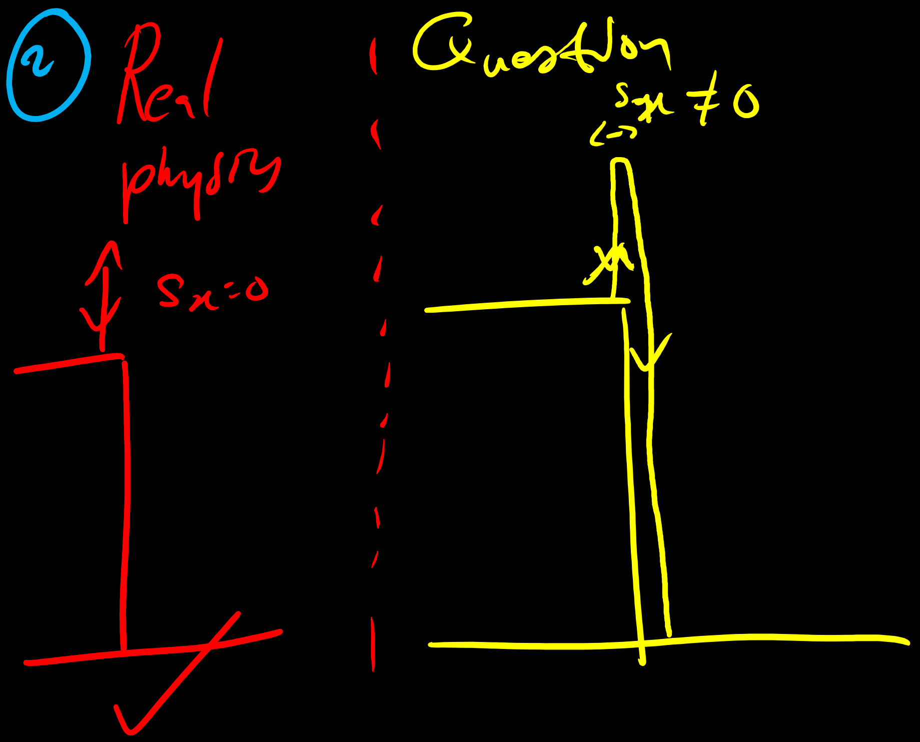
2. A ball is projected upward from the top of the building with a speed of $20\,\mathrm{m\,s^{-1}}$. After 7.0 s, the ball hits the ground. If the acceleration of free fall is $9.81\,\mathrm{m\,s^{-2}}$, what is the height of the building?

A. 61 m

B. 100 m

C. 245m

D. 385 m



① $MLT^{-1} = L^4T^{-1} \times ML^{-3}$

$M \frac{L^{\cancel{4}1}}{\cancel{L^3}} T^{-1}$

MLT^{-1}

7s : h.

$h = u_y t + \frac{1}{2} a_y t^2$

$= (20\,ms^{-1})(7s) - \frac{1}{2}(9.81)(7s)^2$

≈ -100 m

3. A ball is fired at 30^0 to the horizontal with a speed of $100 \mathrm{m\,s^{-1}}$. What is the horizontal range of the projectile?

A. 50 m

B. 87 m

C. 510 m

D. 882 m

3) $S_y = 0$

$S_y = (100 \mathrm{ms^{-1}} \sin 30)t + \frac{1}{2}(-9.81)t^2$

$0 = (50t) + (-1)(4.905)t^2$

$t = \{0, 10.1937\}$.

$50 - 4.905t = 0$

$t = \frac{50}{4.905}$

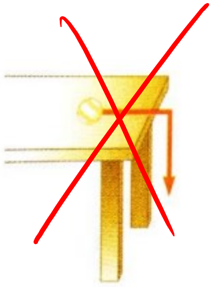
$S_x = 100 \cos 30 (10.1937)$

$\approx 882 \mathrm{m}.$

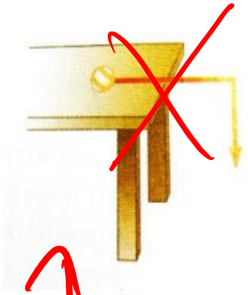
$R = U_x t$

4. A tennis ball is moving with initial horizontal velocity on a surface of a table. Which of the diagrams describe the motion of the ball as it rolls off the table?

A

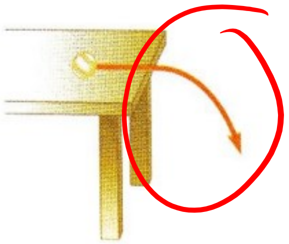


B



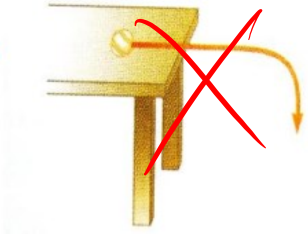
Only in cartoon

C



parabolic

D



5. A 0.10 kg object moving initially with a velocity of 0.20 m s^{-1} to the right makes an elastic head-on collision with a 0.15 kg object initially at rest. Calculate is the final velocity of the 0.10 kg object after the collision if final velocity of 0.15 kg object is 0.107 m s^{-1} to the right?

A. 0.16 m s^{-1} to the right
B. 0.16 m s^{-1} to the left
C. 0.04 m s^{-1} to the left
D. 0.04 m s^{-1} to the right

$+x$

$-x$

6. An object of mass m moves to the right with a speed v. It collides head-on in a perfectly inelastic collision with an object of twice the mass but half the speed moving in the opposite direction. What is the speed of the combined mass after the collision?

A 0
B $v/2$
C v
D $2v$

(6) $\Delta p = 0$,

$$m(+v) + (2m)\left(-\frac{v}{2}\right) = (m+2m)\,☺$$

$$\frac{mv - mv}{3m} = ☺$$

$$☺ = 0 \text{ m s}^{-1}$$

(5) $\Delta p = 0$,

$$m_{Ai}(+0.2) = m_{Af}(v_{fA}) + (m_{Bf})(+0.107)$$

$$(0.1)(0.2) = (0.1)(v_{fA}) + (0.15)(0.107)$$

$$v_{fA} = +0.0395 \text{ m s}^{-1}$$

7. A crane lifts an object, W= 500 N using the arrangement of ropes as shown in Diagram 1. What is the tension, T.

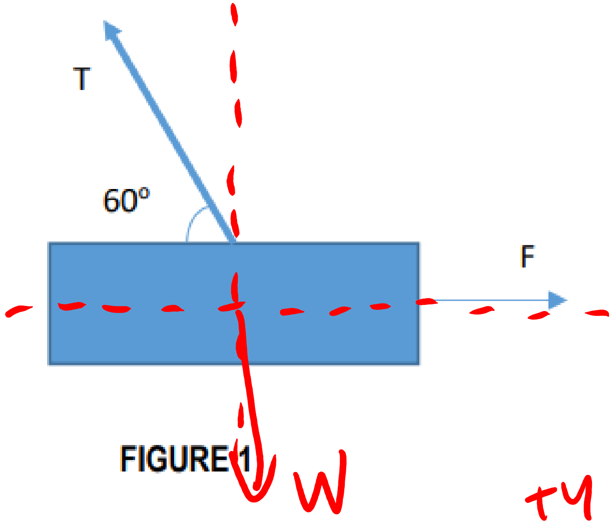
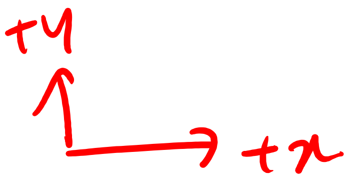


FIGURE 1

A. 480.16 N
B. 577.35 N
C. 316.50 N
D. 450.65 N



(Assume constant velocity)

$\sum F_x = 0$

$\sum F_y = 0$

$T \sin 60 - W = 0$

$T = \dfrac{W}{\sin 60} \Rightarrow T = \dfrac{500}{\sin 60}$

$\sum F_x = F - T \cos 60$

$\sum F_y = T \sin 60 - W$

$T = \dfrac{F}{\cos 60}$

$T = 577.35\text{N}$

8.

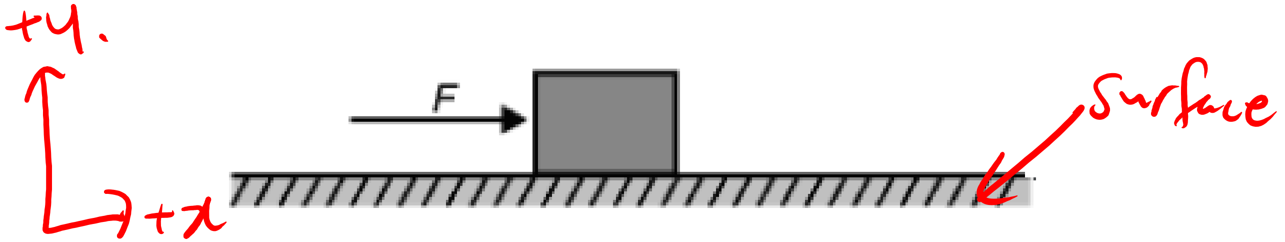


FIGURE 2

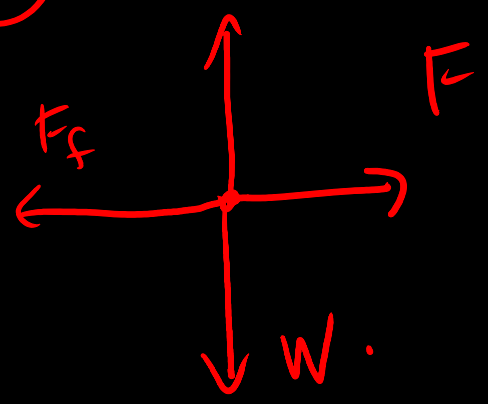
A 10.0 kg block on a horizontal surface with a horizontal force F applied to it is shown in the diagram 2. The coefficient of friction between the block and the surface is 0.70. Calculate the minimum value of F to slide the block.

A. 953.20 N
B. 623.15 N
C. 68.67 N
D. 850.55 N

just enough to overcome friction

$F_{app} \simeq 68.67\,N$

8



$\sum F_y = R - W = 0$

$R = W = 98.1\,N.$

$\sum F_x = F_{app} - F_f = 0$

$F_{app} = \mu N = \mu W = (0.7)(98.1).$

9.

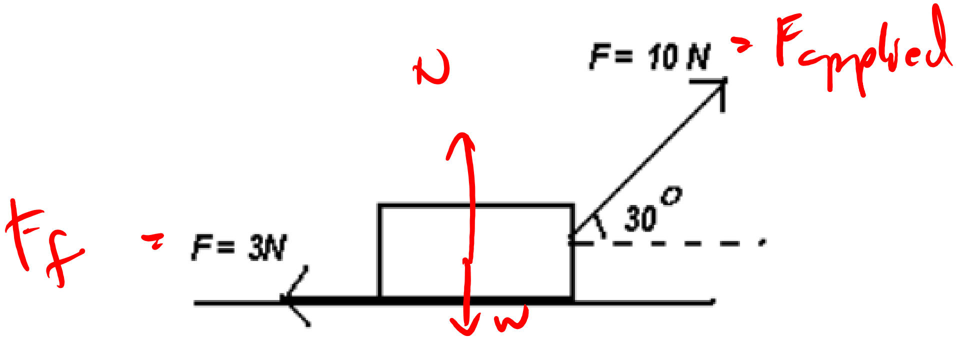
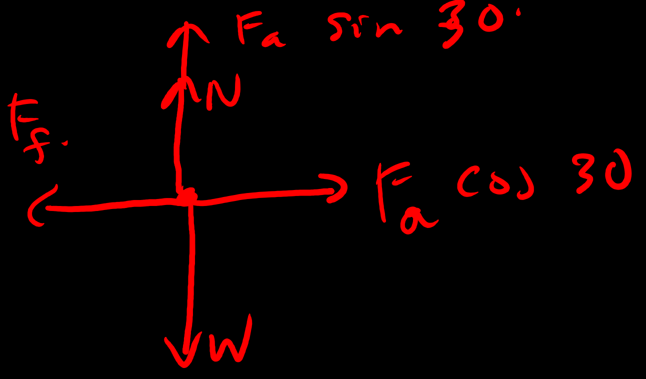


FIGURE 3



A 12.0 kg box on a horizontal surface with a horizontal force F applied to it is shown in the diagram. Given magnitude for F is 10 N and the friction force is 3 N. If the box is displace 2m to the right with constant velocity, calculate total work done by the forces that exerted on the box.

$\sum F_x = 0 = \sum F_y$.

A. 40.62 J

B. 73.26 J

C. 14. 58 J

D. 11.30 J

$\sum F_x = F_a \cos 30 - F_f$

$W_T = (\sum F_x)(s_x)$.

$= (F_a \cos 30 - F_f)(2)$

$= (10 \cos 30 - 3)(2)$

$W = 11.3$ J.

10. An object of mass 0.30 kg is attached to the end of string and supported by a smooth horizontal surface. The object moves in a horizontal circle of radius 0.60 m with a uniform speed of 3.0 m s^{-1}. Calculate the centripetal force.

A. 4.5 N
B. 45 N
C. 0.45 N
D. 450 N

10

$F_c = ma_c$

$= \frac{mv^2}{r}$

$F_c = \frac{(0.3)(3)^2}{0.6}$

$\approx 4.5 \text{ N}$

Thank you!

30 November 2021

11. A car with power 200 kW produces a constant force of 6000 N. Calculate velocity of the car at this power.

A. 3.33 ms^{-1}
B. 33.33 ms^{-1}
C. 2.22 ms^{-1}
D. 22.22 ms^{-1}

$F_f = 0$

12. An object of mass 5 kg is pushed along a smooth horizontal surface with a force 40 N. Find velocity of object after it has moved 5.0 m if it starts from rest.

work done

A. 8.94 ms^{-1}
B. 89.94 ms^{-1}
C. 98.98 ms^{-1}
D. 0.8819 ms^{-1}

$40(\cancel{5}) = \frac{1}{2}\cancel{5}(V_f^2)$

$V_f^2 = 80$

$V_f = 8.95\,ms^{-1}$

11 $P_{ins} = Fv.$

$200(\cancel{10^3}) = 6\cancel{000}(v)$

$\frac{200}{6} = v \approx 33.33\,ms^{-1}$

12 $m = 5k$

$F_{app} = 40N$

$W = \Delta E_k$

work done

$F_{app}(s) = \frac{1}{2}m(V_f^2 - V_i^2)$

40, 5, 5, 0

13. Determine the speed of a satellite moving in a circular orbit about the Earth at a height of 3200km above the Earth's surface. Given $Mass\ Earth = 6 \times 10^{24}\ kg$, $R_E = 6.4 \times 10^6$ m, $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}.

A. $6.46 \times 10^3\ ms^{-1}$
B. $7.91 \times 10^3\ ms^{-1}$
C. $11.18 \times 10^3\ ms^{-1}$
D. $6.67 \times 10^3\ ms^{-1}$

14. Calculate the gravitational force between the Sun and Earth using the fact that the Earth's orbit around the Sun is 365 days and its orbital radius is $1.496 \times 10^{11}\ m$. Given $Mass\ Earth = 6 \times 10^{24}\ kg$

A. $3.56 \times 10^{22}\ N$
B. $5.98 \times 10^{24}\ N$
C. $1.99 \times 10^{30}\ N$
D. $6.67 \times 10^{11}\ N$

14

$$T = 2\pi \sqrt{\frac{r^3}{GM}}$$

mass of source (sun.

$$M_{sun} = \left[\frac{\left(\frac{T}{2\pi}\right)^2 G}{r^3} \right]^{-1}.$$

$$= \left[\frac{\left(\frac{365 \times 24 \times 60 \times 60}{2\pi}\right)^2 (6.67 \times 10^{-11})}{(1.496 \times 10^{11})^3} \right]^{-1}.$$

$$M_s \simeq 1.99 \times 10^{30}\ kg$$

$$F_g = \frac{(6.67)(1.99)(6)}{(1.496 \times 10^{11})^2} \left[10^{-11+30+24}\right].$$

$$F_g \simeq 3.5585 \times 10^{22}\ N$$

13

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$V = \sqrt{\frac{GM_s}{r}}$$

$$V = \left[\frac{6.67(6)}{6.4 + 3.2} \left(10^{-11+24-6}\right) \right]^{1/2}$$

$$V \simeq 6.46 \times 10^3\ ms^{-1}$$

13. Determine the speed of a satellite moving in a circular orbit about the Earth at a height of 3200km above the Earth's surface. Given $Mass\ Earth = 6\times10^{24}\ kg$, R_E=6.4x10^6 m, G=6.67x10^{-11}N m^2 kg^{-2}.

A. $6.46\times10^3\ ms^{-1}$
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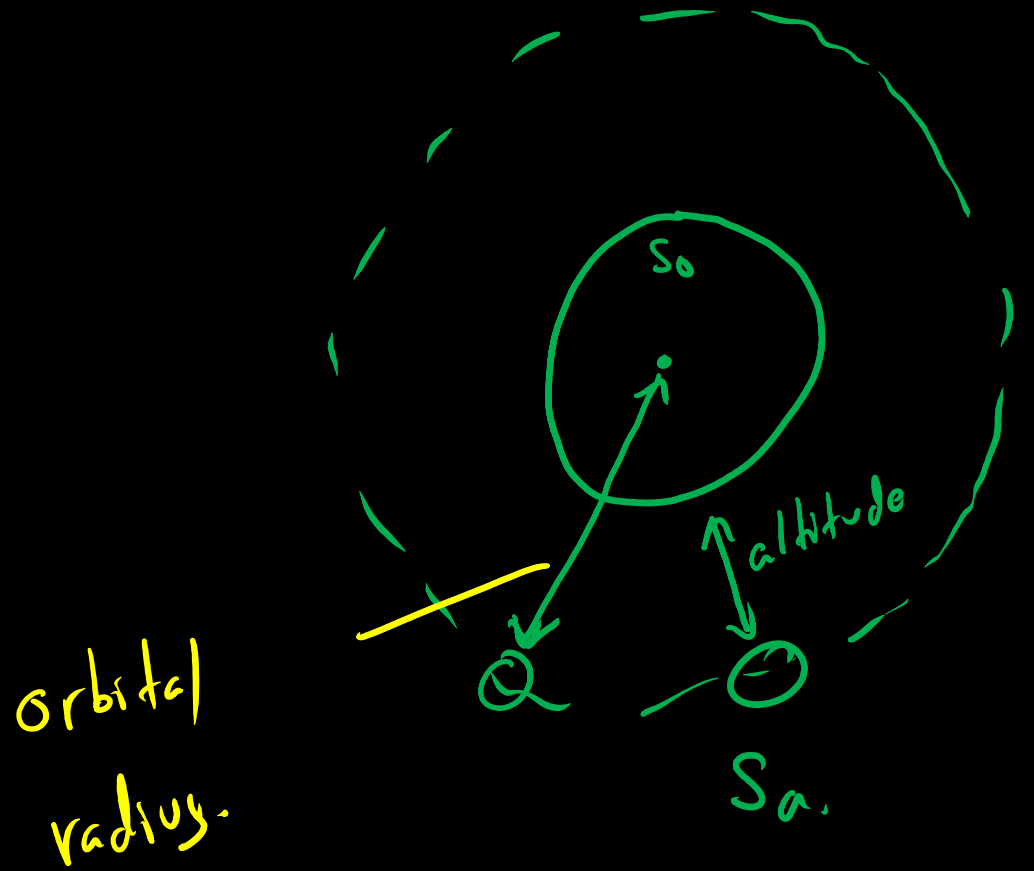


15. A particle is performing simple harmonic motion with displacement, x. if x is given as $x = 30\sin 20t$ where t is the time in second, what is the frequency of the system?

A. $\frac{\pi}{10} Hz$

B. $\frac{10}{\pi} Hz$

C. $\frac{\pi}{30} Hz$

D. $\frac{30}{\pi} Hz$

15

$x(t) = 30 \sin 20t$

$x(t) = A \sin \omega t$

$\omega = 20 \text{ rad s}^{-1} = 2\pi f$

$f = \frac{20}{2\pi} = \frac{10}{\pi} Hz$

16. A 3.0 kg body oscillates in a simple harmonic motion. If its kinetic energy, K changes with displacement x as shown in **FIGURE 4**, Calculate its maximum acceleration?

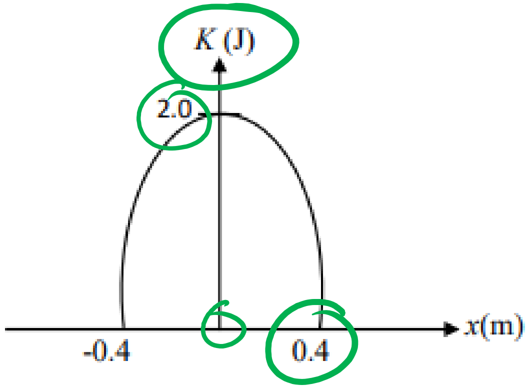


FIGURE 4

A. $3.33\ \text{ms}^{-2}$
B. $3.32\ \text{ms}^{-2}$
C. $2.31\ \text{ms}^{-2}$
D. $2.33\ \text{ms}^{-2}$

17. A particle performs a simple harmonic motion according to equation

$$a = -\omega^2 x = \left(2\sin\frac{\pi}{2}t\right)(-\omega^2)$$

where x is the displacement in metre and t is the time in second. When $t = 2$s, the acceleration of the particle is

A. $0\ \text{ms}^{-2}$
B. $-3.92\ \text{ms}^{-2}$
C. $4.93\ \text{ms}^{-2}$
D. $3.92\ \text{ms}^{-2}$

SHM : $a = -\omega^2 x$

$a_{max} = -\omega^2 A$

$E_k = \frac{1}{2}m\omega^2(A^2 - x^2)$.

$\cancel{\frac{1}{2}m\omega^2 x^2}$ 0

$\left[\frac{1}{2}m\omega^2(A^2 - x^2)\right]$ maximize

at the equilibrium, $x = 0$

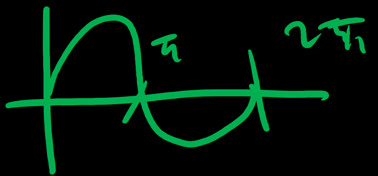
$E_k = 2 = \frac{1}{2}(3)\omega^2(0.4^2 - 0^2)$

$\omega \approx 2.89\ \text{rad s}^{-1}$.

$a_{max} = (2.89)^2(0.4)(-1)$

$\approx 3.34\ \text{ms}^{-2}$

(17)



$a = -\omega^2 x$

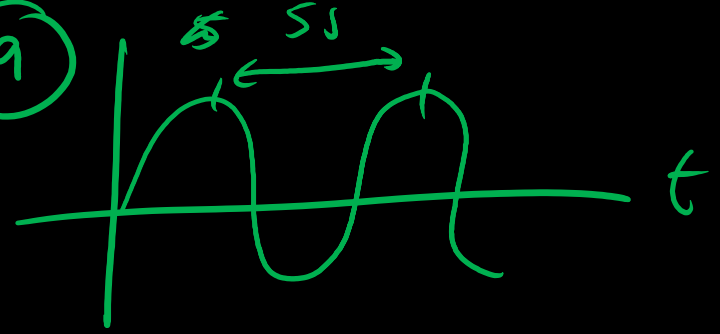
18. A 5 g mass of simple pendulum has angular velocity 8.0 rads^{-1}. Calculate the period of the pendulum.

A. 0.79 s
B. 0.80 s
C. 0.69 s
D. 0.59 s

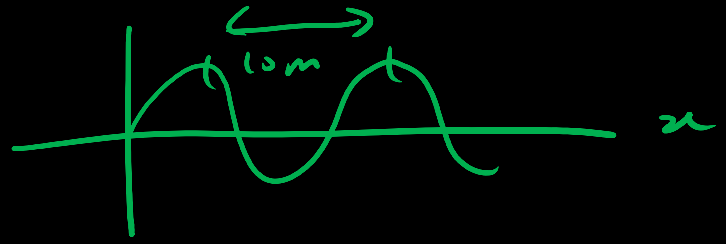
19. A fisherman notices the crests of water waves every 5 second and the distance between each crests is 10 m. How fast is the waves travelling?

A. 0.5ms^{-1}
B. 5ms^{-1}
C. 20ms^{-1}
D. 2ms^{-1}

19



$T = 5s$



$\lambda = 10m$

$V = f\lambda = \frac{\lambda}{T} = \frac{10}{5}$

$V = 2ms^{-1}$

D

18

$\omega = 2\pi f = \frac{2\pi}{T}$

$T = \frac{2\pi}{\omega} = \frac{2\pi}{8} = \frac{\pi}{4} \simeq 0.785398\ s.$

A

20. A wire of mass 5.40×10^{-4} kg is stretched by a force of magnitude 80N. The frequency of the second overtone produced by the vibrating wire is 990 Hz. Determine the length of the wire.

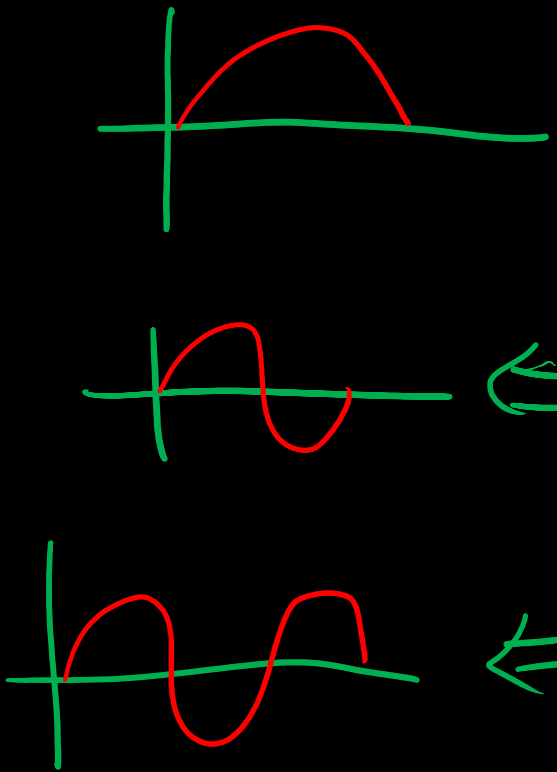
A. 0.34m
B. 0.68m
C. 0.75m
D. 1.00m

(20) $M_{wire} = 5.4(10^{-4})\,kg$

$T = 80N$

$f_{\text{2nd overtone}} = 990Hz.$

$l?$



$\Leftarrow f = 330Hz$

$\Leftarrow f = 666Hz$

$\Leftarrow f = 990Hz$

$$f_0 = \overbrace{\frac{1}{2l}}^{\lambda}\overbrace{\sqrt{\frac{T}{\mu}}}^{v}$$

$$l = \frac{1}{2f_0}\sqrt{\frac{Tl}{m}}$$

$$l = \frac{1}{2(330)}\sqrt{\frac{80l}{5.4(10^{-4})}}$$

$l = 0.34\,m.$ #

Thank you!

1st December 2021

21. A man and a stationary sound source which can produce sound of frequency 300 Hz lie on the same horizontal straight line. Determine the frequency of sound heard by the man if he moves away from source at constant speed 15 m s^{-1}. The speed of sound in air = 330 m s^{-1}.

A. 250Hz
B. 277Hz
C. 286Hz
D. 500Hz

Doppler effect.

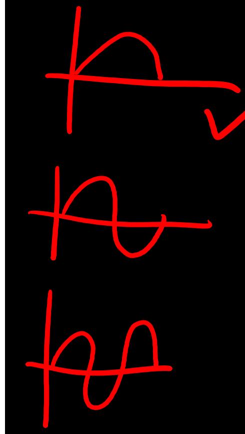
22. Find the speed of waves on a violin string of a mass 800 mg and length 22.0 cm if the fundamental frequency is 920 Hz.

A. 3.64 m/s
B. 37.0 m/s
C. 340 m/s
D. 405 m/s

stretched string

22

$v = f\lambda$



$l = \frac{\lambda}{2} \Rightarrow \lambda = 2l$

$V = f(2l)$

$= (920)(2)(22\times10^{-2})$

$V \approx 404.8\ ms^{-1}$ #

21

$f_{app} = \left(\frac{V \pm V_o}{V \cancel{\mp V_s}^{\,0}}\right) f_s$

$f_{app} = \left(\frac{V - 15}{V}\right) f_s$

$f_{app} = \left(\frac{330 - 15}{330}\right)(300Hz)$

$f_{app} \approx 286.364\ Hz$

23. A teenage girl standing at the side of the road hearing a sound of frequency 600 Hz when a police car is approaching her. If the police car's siren produce a 500 Hz of frequency, calculate the velocity of the police car. (Given speed of sound in the air = 340m/s)

A. 30.9 m/s
B. -68.0 m/s
C. 56.7 m/s
D. 68.0 m/s

Doppler effect

24. A copper wire of a cross-sectional area of $3mm^2$ is stretched 0.1 mm by using a certain force. How far will a wire of the same material and the same length stretch if the cross-sectional area is 6 mm^2 experience the same force?

A. 0.05 mm
B. 0.1 mm
C. 0.2 mm
D. 0.4 mm

24

$A_{old} = 3\ mm^2$

$\Delta l = 0.1mm$

Same material

Same length

$6\ mm^2 = A_{new}$

$Y = \frac{\sigma}{\varepsilon} = \frac{F}{A}\left(\frac{\Delta l}{l}\right)^{-1}$

$\left.\begin{array}{l} Y_{new} = Y_{old} \\ l_{new} = l_{old} \\ F_{new} = F_{old} \end{array}\right\}$

constants | changes

$\frac{Y}{Fl} = \frac{1}{A\Delta l} \Rightarrow A\Delta l = \boxed{\frac{Fl}{Y}}$

$(A\Delta l)_{new} = (A\Delta l)_{old}$

$\frac{A_{new}}{A_{old}} = \frac{\Delta l_{old}}{\Delta l_{new}} \Rightarrow \frac{6}{3} = \frac{0.1}{\Delta l_{new}}$

$\Delta l_{new} = 0.05mm$

23

$\frac{f_{app}}{f_s} = \frac{V}{V \mp V_s}$

$\frac{600}{500} = \frac{340}{340 - V_s}$

$6(340 - V_s) = 5(340)$

$340 - \frac{5}{6}(340) = V_s$

$V_s \approx 56.67\ ms^{-1}$

C

25. A surface of thermal insulator has a cross sectional area 400 cm^2 and thickness 5.0 cm. Its thermal conductivity is 0.3 $Wm^{-1}\,^{\circ}C^{-1}$. If the temperature different between opposite surface is 85 ˚C, calculate the rate of heat flow through the surface.

A. 20.4 Js^{-1}
B. 2.04 Js^{-1}
C. 0.32 Js^{-1}
D. 32.0 Js^{-1}

$(cm)^2 = (10^{-2}\,m)^2$

$cm^2 = 10^{-4}\,m^2$

26. A metal tape has a length of 100 cm at 20 ˚C. Calculate the change in length when its temperature is raised to 70 ˚C. (Given the coefficient of linear expansion, α =1.2x10^{-5} K^{-1})

A. 0.06 cm
B. 0.60 cm
C. 0.30 cm
D. 0.03 cm

linear thermal expansion $\Rightarrow \alpha$.

(26) $\alpha = \frac{\Delta l}{l_0}\,\Delta T$.

$\Delta l = \alpha\, l_0\, \Delta T$ in metre

$= 1.2(10^{-5})(1)(50°C)$

$\Delta l = 6\times10^{-4}\,m$.

$= 6\times10^{-2}(\times10^{-2}\,m)$

$\Delta l = 6\times10^{-2}\,cm$ #

(25) $400\,cm^2 = A$

$t = 5\,cm$

$K = 0.3\,Wm^{-1}C^{-1}$

$\Delta T = 85°C$

$\frac{dQ}{dt} = -kA\frac{\Delta T}{\Delta x}$

$\frac{dQ}{dt} = -(0.3)(400\times10^{-4})\left(\frac{85}{5\times10^{-2}}\right)$

$\frac{dQ}{dt} = -20.4\,Js^{-1}$

27. In the lungs, a thin respiratory membrane separates tiny sacs of air (absolute pressure = 1.00 X 10^5 Pa) from the blood in the capillaries. These sacs are called alveoli. The average radius of the alveoli is 0.125 mm. Assuming that the air behaves as an ideal gas at body temperature (310 K), calculate the number of molecules of air in one of the sacs.

A. 2.7 X 10^{13}
B. 1.9 X 10^{14}
C. 1.3 X 10^{13}
D. 2.0 X 10^{14}

28. Given the molar mass of oxygen is 32 g, Calculate the root mean square speed of the oxygen molecules at a temperature of 60 °C.

A. 16 ms^{-1}
B. 100 ms^{-1}
C. 216 ms^{-1}
D. 509 ms^{-1}

28

$$\frac{1}{\cancel{2}}\cancel{m}v^2 = \frac{3}{\cancel{2}}RT.$$

$$V_{rms} = \sqrt{\frac{3RT}{m}}$$

$$V_{rms} = \left[\frac{3(8.31)(60+273)}{0.032}\right]^{1/2}$$

$$V_{rms} \approx 509.341\,ms^{-1}$$

27 Ideal gas equation.

$$pV = nRT = Nk_BT.$$

\# of mol

\# of molecules

$$N = \frac{pV}{k_BT}$$

$$N = \frac{(1)\left(\frac{4\pi}{3}(0.125)^3\right)}{(1.38)(310)}\left[10^{5-3(3)+23}\right]$$

$$N = 1.9\times10^{14} \text{ molecules.}$$

29. Work of 500 J is done on the system by absorbing 2000 J of heat. Determine the change in internal energy of the system.

U ↑ U ↑

A. 1500 J
B. 2500 J
C. -1500 J
D. -2500 J

29

$\Delta U = \Delta Q + W$

heat into

onto.

$\Delta U = 2000 + 500$

$\Delta U = 2500\,J.$

30.

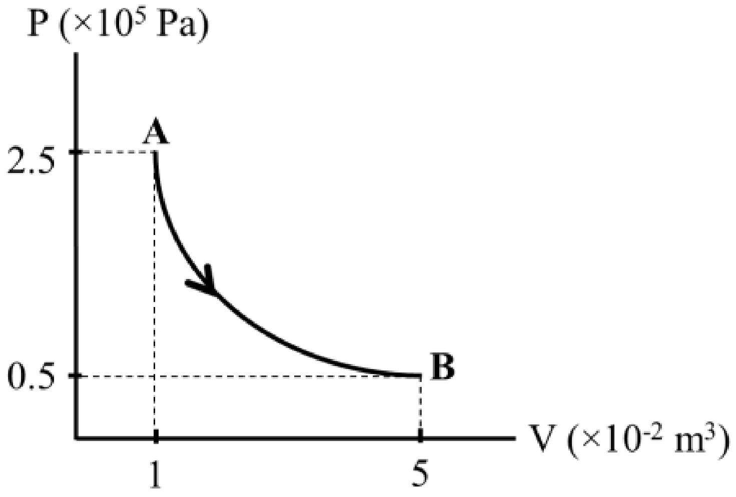


FIGURE 2 $\Delta T = 0$

A 1.0 mole ideal gas undergoes isothermal process AB at a temperature of 300 K as shown in **FIGURE 1**. Given R = 8.31 J mol^{-1} K^{-1}. Calculate the work done in the process AB.

A. 8000.00 J
B. -8000.00 J
C. 4012.33 J
D. -4012.33 J

$$W = \int p \, dV \quad ; \quad pV = nRT$$

$$W = \int \frac{nRT}{V} dV$$

$$W = nRT \int_{V_A}^{V_B} \frac{1}{V} dV$$

$$W = nRT \left[\ln V_B - \ln V_A \right] = nRT \ln \left[\frac{V_B}{V_A} \right]$$

$$W = (1)(8.31)(300\,\mathrm{K}) \ln \left[\frac{5}{1} \right]$$

$$W = 4012.33\,\mathrm{J}$$

Thank you!

2nd November 2021

Chapter 10

$\lambda, k \Rightarrow k = \frac{2\pi}{\lambda}$

$\omega, f \Rightarrow \omega = 2\pi f$

$\Downarrow$

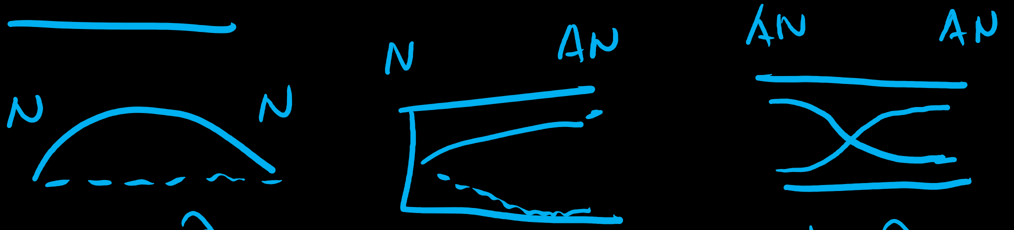
GE: $y(x,t) = A \sin(\omega t \pm kx)$

Doppler effect

$$\frac{f'}{f} = \left(\frac{V \pm V_0}{V \mp V_s}\right) = \frac{\lambda}{\lambda'}$$

$V = f\lambda$

Sound wave



$L = \frac{\lambda}{2}$ $\quad L = \frac{1}{4}\lambda$ $\quad L = \frac{\lambda}{2}$

$I \propto \frac{1}{r^2}$

Standing wave

$A \sin(\omega t + kx) + A \sin(\omega t - kx)$

$= 2A$ ......

{ GE.
Doppler effect.
Sound wave

{ standing wave
or
sound intensity

Chapter 9

GE : $x(t) = A \sin(\omega t)$

constant

$T = \frac{2\pi}{\omega}$

$\omega = 2\pi f$

$\omega_{\text{simple pendulum}}$

$\omega_{\text{spring system}}$

$T_{s.p.}$

$T_{s.s.}$

Energy

$E_k(t)$ $E_p(t)$

$E_k(x)$ $E_p(x)$

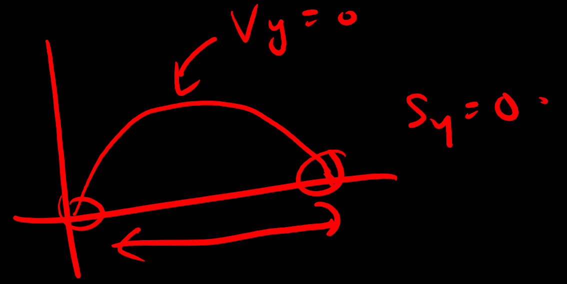
graph

$E_T(A)$

Chapter 2

peak $\Rightarrow V_y = 0$

range $\Rightarrow S_y = 0.$



Chapter 5

↳ ~~for~~ requires understanding from previous chapters

↳ $W = \vec{F} \cdot \vec{S}$

$W_T = (\vec{F}_1 + \vec{F}_2 + \ldots) \cdot \vec{S} = \left(\sum_i F\right) \cdot S$

$W_{F_i} = \vec{F}_i \cdot \vec{S}$

$W = \Delta K$

Chapter 7

1

$F = \frac{GMm}{r^2} = m\, a_g$

$E = F \cdot r = -\frac{GMm}{r}$

2 escape velocity

3 satellite

relating to circular motion

$\frac{mv^2}{r}$; T

Chapter 13

① Ideal gas equation

V_{rms}

Ideal gas eqn + V_{rms}

$p(V_{rms})$

$V(V_{rms})$

② energy

equipartition theorem

for one atom

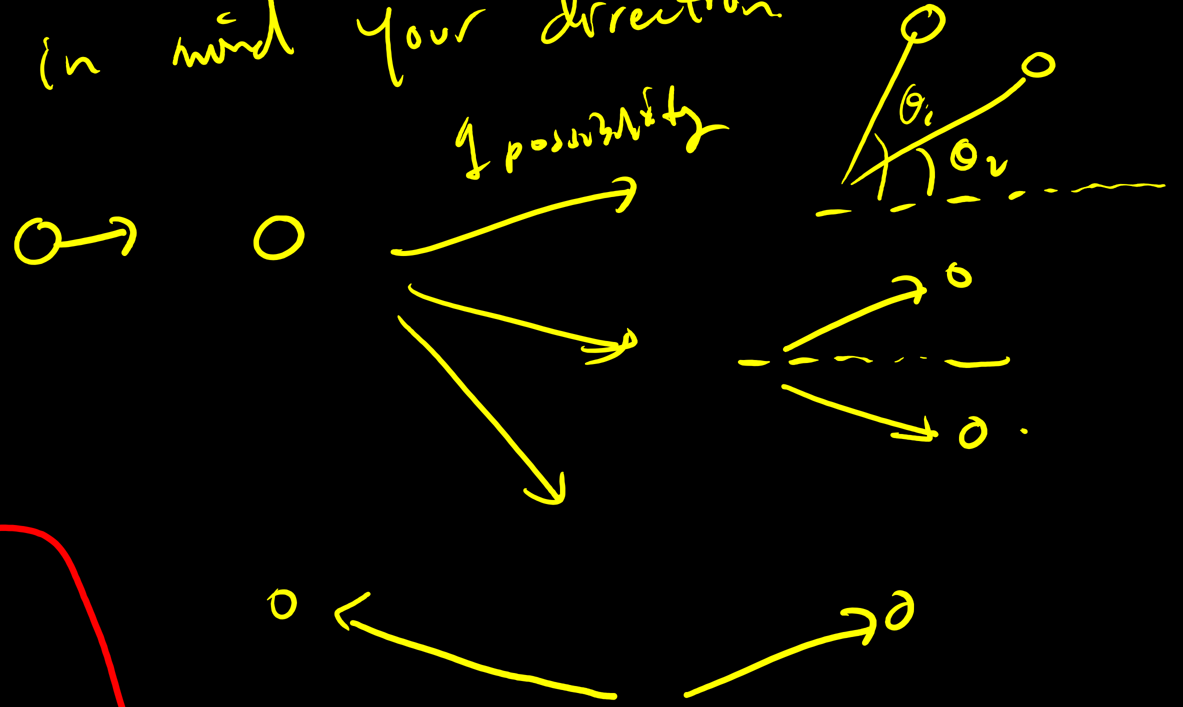
for many atom

mono : $U_T = KTR$.

diatoms : $U_T \neq KTR$.

Chapter 3

bear in mind your direction



Chapter 4

4 forces

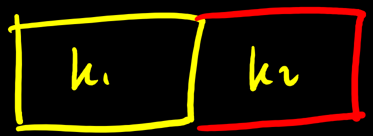
Smooth/frictionless

pulley system

mind the direction

Chapter 12

heat



steady-state

$$\frac{dQ_T}{dt} = \frac{dQ_1}{dt} = \frac{dQ_2}{dt}$$

Thermal expansion

$$\frac{\Delta L}{L} = \alpha \Delta T.$$

Chapter 14

$$\left.\begin{array}{l} \Delta U = \Delta Q + \Delta W \\ \Delta U = \Delta Q - \Delta W \end{array}\right\} \text{different def. of } W.$$

Check processes (TD)

$\downarrow$

determine eqn. for W

e.g. isobaric — expansion or compression

$P = \text{constant}$

$W = p(V_f - V_i)$

Chapter 6.

$$F_c = ma_c = \frac{mv^2}{r}$$

mind your units

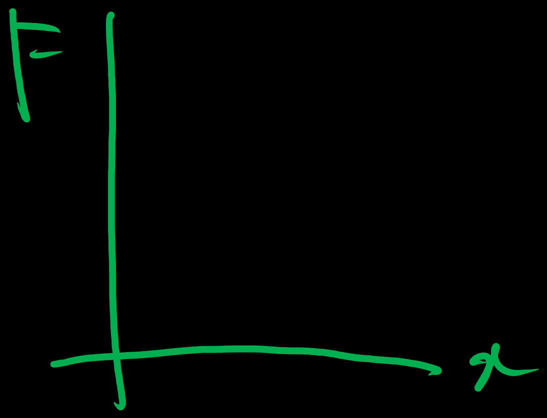
- FBD.
- determine which direction

F_c

- vertical, horizontal
  conical pendulum

Chapter 11

$$Y = \frac{\sigma}{\varepsilon} = \frac{F}{A}\left(\frac{\Delta L}{L}\right)^{-1}$$



gradient

area under graph

Thank you!