Sarawak Matriculation College, SP015


# Question Bank

$$\frac{\delta S}{\delta q(t)} = 0$$

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# Contents


**1 Physical Quantities and Measurements** **4**
- 1.1 Dimensions of physical quantities . . . 4
- 1.2 Scalars and Vectors . . . 4

**2 Kinematics of Linear Motion** **5**
- 2.1 Linear Motion . . . 5
- 2.2 Uniformly accelerated Motion . . . 5
- 2.3 Projectile motion . . . 6

**3 Momentum and Impulse** **8**
- 3.1 Momentum and Impulse . . . 8
- 3.2 Conservation of Linear Momentum . . . 8

**4 Forces** **10**
- 4.1 Basics of forces and free body diagram . . . 10
- 4.2 Newton's Laws of Motion . . . 10

**5 Work, Energy and Power** **13**
- 5.1 Work . . . 13
- 5.2 Energy and Conservation of Energy . . . 14
- 5.3 Power . . . 15

**6 Circular Motion** **16**
- 6.1 Uniform Circular Motion . . . 16
- 6.2 Centripetal Force . . . 16

**7 Gravitation** **19**
- 7.1 Gravitational force and field strength . . . 19
- 7.2 Gravitational Potential Energy . . . 19
- 7.3 Satellite motion in a circular orbit . . . 20

**8 Rotation of Rigid Body** **22**
- 8.1 Rotational Kinematics . . . 22
- 8.2 Equilibrium of a uniform rigid body . . . 23
- 8.3 Rotational Dynamics . . . 24
- 8.4 Conservation of angular momentum . . . 25

**9 Simple Harmonic Motion** **26**
9.1 Kinematics of Simple Harmonic Motion . . . 26
9.2 Graphs of simple harmonic motion . . . 27

**10 Mechanical and Sound Waves** **28**
10.1 Properties of Waves . . . 28
10.2 Superposition of Waves . . . 28
10.3 Application of standing waves . . . 29
10.4 Doppler Effect . . . 29

**11 Deformation of Solids** **30**

**12 Heat Conduction and Thermal Expansion** **32**
12.1 Heat conduction . . . 32
12.2 Thermal Expansion . . . 32

**13 Gas Laws and Kinetic Theory** **34**
13.1 Ideal Gas Equation . . . 34
13.2 Kinetic Theory of Gases . . . 34
13.3 Molecular kinetic energy and internal energy . . . 34

**14 Thermodynamics** **36**
14.1 First Law of Thermodynamics . . . 36
14.2 Thermodynamics processes . . . 36
14.3 Thermodynamics work . . . 36

# 1 Physical Quantities and Measurements

## 1.1 Dimensions of physical quantities

1. Determine a dimension and the S.I. unit for the following derived quantities:
   a) Linear momentum
   b) Density
   c) Force
   d) Work
2. Convert the following unit into S.I unit
   a) $4.70\ g\ cm^{-3}$
   b) $72\ km\ h^{-1}$
3. Determine whether the following expressions are dimensionally correct or not.
   a) $2s = 2ut + at^2$ where s, u, a and t represent the displacement, initial velocity, acceleration and the time of an object respectively.
   b) $v^2 = u^2 - 2gt$ where t, u, v and g represent the time, initial velocity, final velocity and the gravitational acceleration respectively.
4. Factors influencing the speed $v$ of sound in medium maybe density $\rho$, wavelength $\lambda$ and Young's modulus $E$. On the basis of dimensional analysis, obtain an expression for $v$. ( Take $[E] = ML^{-1}T^{-2}$)

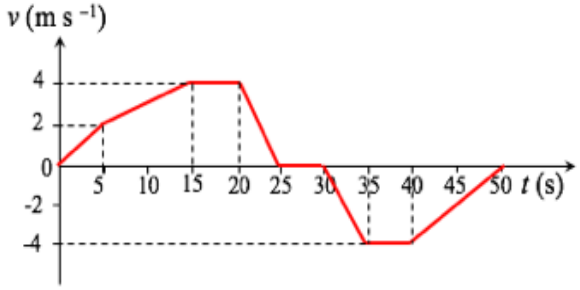
## 1.2 Scalars and Vectors

1. Given vector $\vec{A}$ and $\vec{B}$, such that $\vec{A} = 3\hat{i} - 2\hat{j}$ and $\vec{B} = -\hat{i} - 5\hat{j}$. Determine
   a) the dot product of the two vectors. **[Ans: 7$Nm$]**
   b) the angle between the two vectors. **[Ans: 67.62$^o$]**
   c) the cross product of the vectors.

# 2 Kinematics of Linear Motion

## 2.1 Linear Motion

1. A velocity-time (v-t) graph in the figure below shows the motion of a lift.

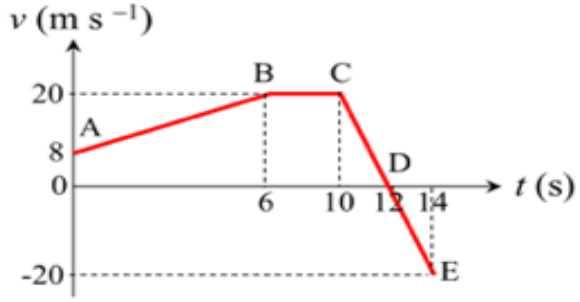



a) Describe qualitatively the motion of the lift.

b) Determine the total distance travelled by the lift and its displacement **[Ans:** $115m; 15m$]

c) Calculate the average acceleration between 20 s to 40 s **[Ans:** $-0.4\ ms^{-2}$]

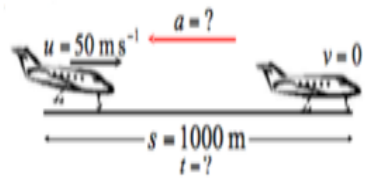
2. The graph below shows the change of velocity with time for an object.




Determine:
a) The acceleration for AB, BC, CD and DE

b) The displacement

## 2.2 Uniformly accelerated Motion

1. 


A plane lands on a runway at velocity $50ms^{-2}$ and decelerates at constant rate. The plane travels 1.0 km before stops. Calculate:

a) the deceleration of the plane **[Ans:** $1.25\ ms^{-2}$]
b) the time taken for the plane to stop **[Ans:** $40\ s$]

2. A car which is initially at rest starts to move along a straight line with constant acceleration. It reaches a velocity of $60ms^{-1}$ after travelling through a distance of 100 m. Determine,

   a) the acceleration **[Ans:** $18\ ms^{-2}$]

b) the time taken to reach the velocity of $60ms^{-1}$ **[Ans:** 3.3 $s$]

c) the velocity at t = 3.0 s. **[Ans:** 170 $ms^{-1}$]

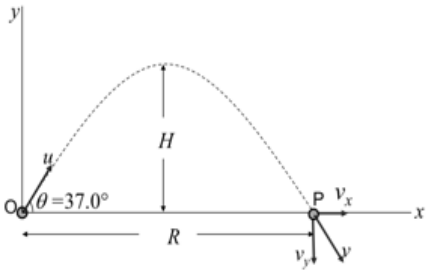
3. A bus travelling steadily at $30ms^{-1}$ along straight road passes a stationary car which, 5 s later, begins to move with a uniform acceleration of $2ms^{-2}$ in the same direction as the bus. Determine;

   a) the time taken for the car to acquire the same velocity as the bus **[Ans:** 40 $s$]

   b) the distance travelled by the car when it is level with the bus. **[Ans:** 900 $m$]

## 2.3 Projectile motion

1. A football is kicked at an angle $\theta = 37^o$ with a velocity of $20.0ms^{-1}$ as shown in the figure. Calculate :




a) The maximum height H **[Ans:** 7.38 $m$]
b) The time of travel before the football hits the ground **[Ans:** 2.45 $s$]
c) How far away it hits the ground **[Ans:** 39.13 $m$]
d) The velocity vector at maximum height. **[Ans:** $v_x = 1.6\ ms^{-1}$ ; $v_y = 0\ ms^{-1}$]
e) The acceleration vector at maximum height **[Ans:** $a_x = 0\ ms^{-2}$ ; $a_y = -9.81\ ms^{-2}$]

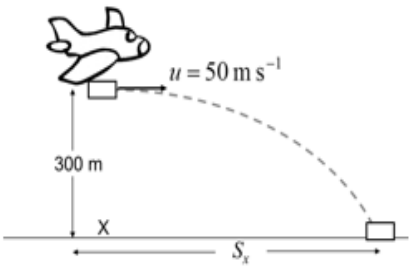
2. A stone is thrown vertically upwards with a speed of $10.0ms^{-1}$ off of the edge of the cliff 65.0 m high. Calculate

   a) the time taken to reach the bottom of the cliff **[Ans:** 4.79 $s$]

   b) the speed of the stone just before hitting the ground **[Ans:** 36.99 $ms^{-1}$]

   c) the total distance travelled. **[Ans:** 75.2 $m$]

3. A transport plane travelling at a constant velocity of $50.0ms^{-1}$ at an altitude of 300 m releases a parcel when directly above a point X on level ground. Calculate




a) The flight time of the parcel **[Ans:** 7.82 $s$]

b) The velocity of impact of the parcel **[Ans:** 1.6 $ms^{-1}$]

c) The distance from X to the point of impact.**[Ans:** 391 $m$]

4. A parcel is dropped from a helicopter that is stationary in the air. If the parcel is moving as a free falling object without air resistance, determine
   a) the height of the parcel after 3.0 s **[Ans:** 44.15 $m$]
   b) the velocity of the parcel after falling 80 m **[Ans:** 39.62 $ms^{-1}$]
   c) the time taken by the parcel to reach a velocity of $30.0ms^{-1}$ **[Ans:** 3.06 $s$]
5. A projectile is shot from the edge of a cliff 125 m above ground level with an initial speed of $65.0ms^{-1}$ at an angle of $37^o$ to the horizontal as shown in FIGURE 3.

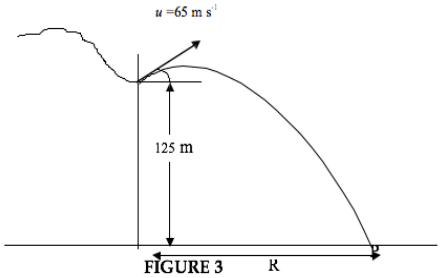


FIGURE 3

a) Determine the time taken by the projectile to hit point P at ground level **[Ans:** 10.42 $s$]

b) Determine the range R **[Ans:** 540.92 $m$]

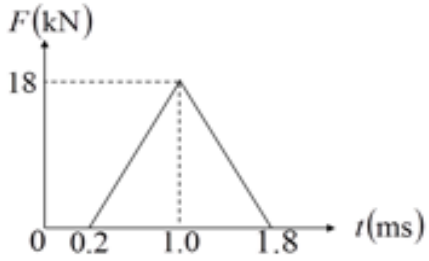
c) Calculate the velocity of the projectile just before it hits point P **[Ans:** 81.5 $ms^{-1}$]

6. An object A is launched with initial velocity $120.0ms^{-1}$ at an angle $50^o$ with the horizontal. Simultaneously, another object, B is thrown vertically at another location. If A and B collide in the air, calculate the velocity of B when it thrown upward.

# 3 Momentum and Impulse

## 3.1 Momentum and Impulse

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 **[Ans:** 2.5 $kg\ ms^{-1}$]
   b) Find the impulse of the ball **[Ans:** $-5\ Ns$]
   c) Find the impulsive force on the ball **[Ans:** $-16.67\ N$]
2. A steel ball with mass 40.0 g is dropped from a height of 2.00 m onto a horizontal steel slab. The ball rebounds to a height of 1.60 m.
   a) Calculate the impulse delivered to the ball during impact.**[Ans:** 0.47 $Ns$]
   b) If the ball is in contact with the slab for 2.00 ms, determine the average force on the ball during impact **[Ans:** 237.1 $N$]
3. An estimated force-time curve for a tennis ball of mass 60.0 g struck by a racket is shown in figure.




Determine
a) The impulse delivered to the ball **[Ans:** 0.144 $Ns$]

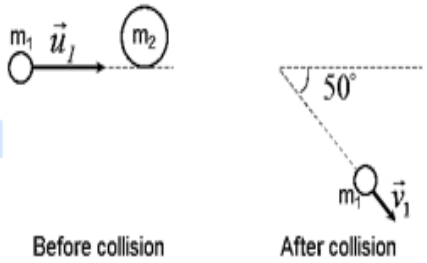
b) The speed of the ball after being struck, assuming the ball is being served so it is nearly at rest initially.**[Ans:** 2.40 $ms^{-1}$]

## 3.2 Conservation of Linear Momentum

1. An object A of mass 200 g is moving with velocity $3ms^{-1}$ to the right collides head-on with an object B of mass 100 g moving with velocity of $6ms^{-1}$ . After the collision, B moves at a speed of $2ms^{-1}$ to the right. Determine the velocity of A after the collision. **[Ans:** 1 $ms^{-1}$ ; $to\ the\ left$]

2. A bullet fired from a pistol has mass of 8.0 g and a muzzle speed of $352 ms^{-1}$ If the mass of the gun is 0.9 kg, what is its recoil speed when fired horizontally? **[Ans:** $-3.13\ ms^{-1}$]

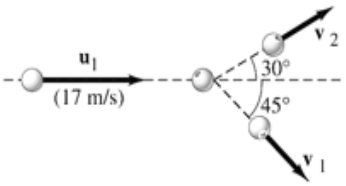
3. A tennis ball of mass $m_1$ moving with initial velocity $u_1$ collides with a soccer ball of mass $m_2$ initially at rest. After the collision, the tennis ball is deflected from its initial direction with a velocity $v_1$ as shown in figure.




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

Calculate the magnitude and direction of soccer ball after the collision.**[Ans:** $4.91\ ms^{-1}$ ; $9.97^o$ *above positive* $x-$ *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 **[Ans:** $8.80\ ms^{-1}$ ; $12.40\ ms^{-1}$]

5. Object A of mass 8 kg moving at $4 ms^{-1}$ collides with another object B of mass 6 kg moving at $5 ms^{-1}$ in the opposite direction. After the collision, object A moves opposite to its initial direction at $0.1 ms^{-1}$.

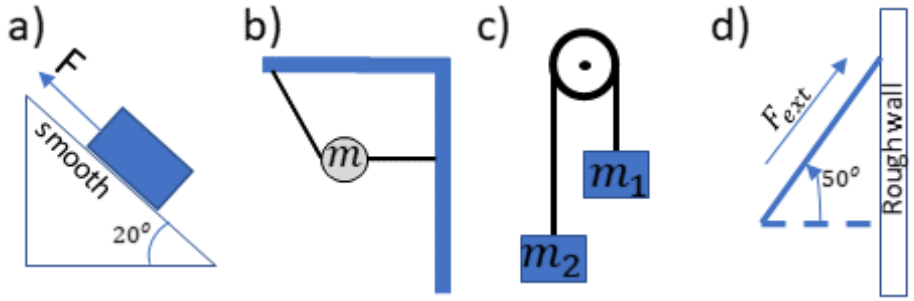
   a) What is the velocity of B after the collision? **[Ans:** $0.467\ ms^{-1}$]

   b) Show that the collision is inelastic.

# 4 Forces

## 4.1 Basics of forces and free body diagram

1. Draw a free body diagram for each cases below:




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.

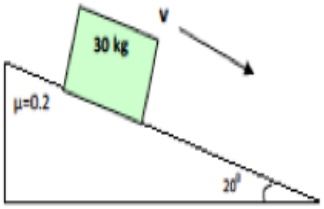



FIGURE 4.8

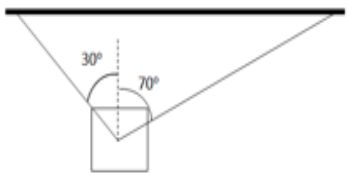
The coefficient of kinetic friction between the block and the inclined plane is 0.2.

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 **[Ans:** 55.31 $N$]

## 4.2 Newton's Laws of Motion

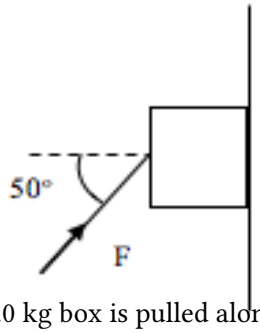
1. Syafiee, Akmal and Masnah find three ropes tied together with a single knot and decide to have three-way tug-of-war. Masnah pulss to the west with 100 N of force while Akmal pulls to the south with 200 N. How hard, and in which direction, should Syafiee pull to keep the knot from moving? **[Ans:** 223.6 $N$; $63.43^0$]

2. 


An object of weight W = 49 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. **[Ans:** 46.76 $N$; 24.9 $N$]

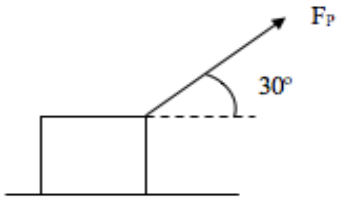
3. A block of mass 3.00 kg is pushed up against a wall by a force F that makes a $50^0$ angle with the horizontal as shown in figure.




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. **[Ans:** 48.62 $N$]

4. A 10.0 kg box is pulled along a horizontal smooth surface by a force $F_p = 40N$ applied at a $30^0$ angle above horizontal.



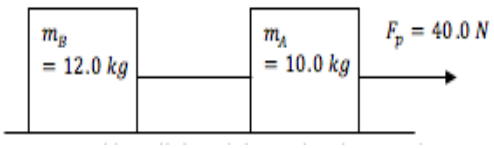

Calculate:

a) The acceleration of the box **[Ans:** 3.46 $ms^{-1}$]

b) The magnitude of normal force exerted by the table on the box**[Ans:** 78.1 $N$]

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. **[Ans:** 1.12 $ms^{-2}$]

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.

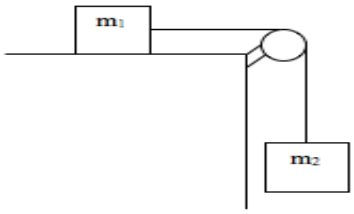



A horizontal force of 40.0 N is applied to 10.0 kg box. Calculate:

a) The acceleration of each box **[Ans:** 1.82 $ms^{-2}$]

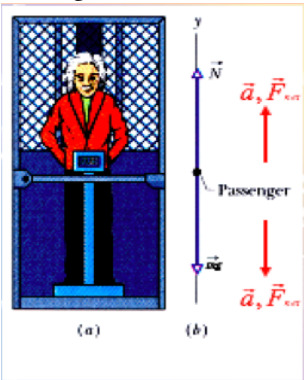
b) The tension in the cord connecting the box **[Ans:** 21.84 $N$]

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 **[Ans:** 3.27 $ms^{-2}$]
c) Calculate the tension in the string **[Ans:** 19.6 $N$]

8. The diagram shows the forces acting on a person in a lift. The person has a mass of 70 kg.



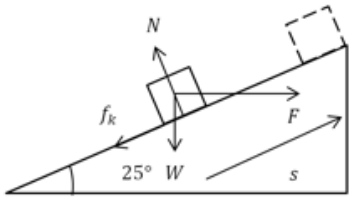

Calculate the normal reaction force, N when:

a) the lift is at rest **[Ans:** 686.7 $N$]
b) the lift is accelerating upwards at $1.0ms^{-1}$ **[Ans:** 756.7 $N$]
c) the lift is accelerating downwards at $2.0ms^{-1}$ **[Ans:** 616.7 $N$]
d) the lift is ascending at a steady speed **[Ans:** 686.7 $N$]

# 5 Work, Energy and Power

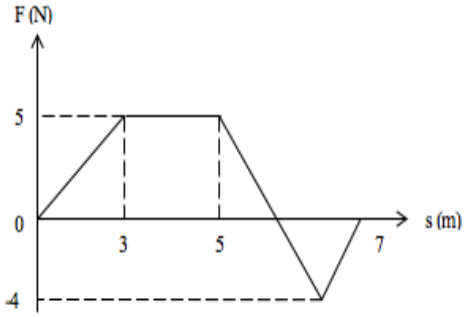
## 5.1 Work

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 **[Ans:** 31.9 $J$]
   b) the normal force exerted by the table **[Ans:** 0 $J$]
   c) the gravitational force **[Ans:** 0 $J$]
   d) Determine the total work on the block **[Ans:** 31.9 $J$]
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 **[Ans:** 861 $J$]
b) the work done on the box by the gravitational force **[Ans:** $-315$ $J$]
c) the work done on the box by the reaction force **[Ans:** 0 $J$]
d) the work done on the box by the frictional force **[Ans:** $-323.16$ $J$]
e) The total work done on the box **[Ans:** 223 $J$]

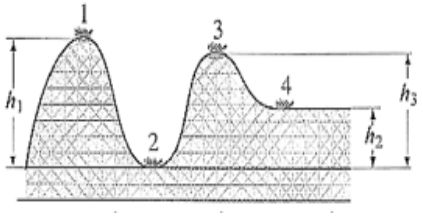
3. A horizontal force F is applied to a 2.0 kg radio-controlled car as it moves along a straight track. The force varies with the displacement of the car as shown in the figure.




Calculate the work done by the force F when the car moves from s = 0 to s = 7 m. **[Ans:** 18 $J$]

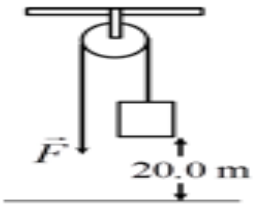
## 5.2 Energy and Conservation of Energy

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



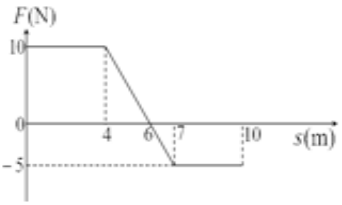

Assuming no friction, calculate the speed at points 2, 3 and 4.
Given that $h_1 = 32m, h_2 = 14m$ and $h_3 = 26m$ **[Ans:** 25 $ms^{-1}$; 10.72 $ms^{-1}$; 18.72 $ms^{-1}$]

2. A 1.5 kg sphere is dropped from a height of 30 cm onto a spring of spring constant, $k = 2000Nm^{-1}$. After the block hits the spring, the spring experiences maximum compression, x as shown in the figure.
    a) Describe the energy conversion occurred after the sphere is dropped onto the spring until the spring experiences maximum compression, x.
    b) Calculate the speed of the sphere just before strikes the spring **[Ans:** 2.43 $ms^{-1}$]
    c) Determine the maximum compression, x. **[Ans:** 0.0743 $m$]
3. A pile driver with mass 10 000 kg strikes a pile with velocity $10ms^{-1}$.
    a) What is the kinetic energy of the drives as it strikes the pile? **[Ans:** $5 \times 10^5$ $J$]
    b) If the pile is driven 20 cm into the ground, what force is applied to the pile by drives as it strikes the pile? **[Ans:** $2.5 \times 10^6$ $N$]
4. In a smooth pulley system, a force F is required to bring an object of mass 5.00 kg to the height of 20.0 m at a constant speed of $3.00ms^{-1}$ as shown in the diagram.




Determine
a) The force, F **[Ans:** 49.05 $N$]
b) The work done by the force, F **[Ans:** 981 $J$]

5. An object of mass 2.0 kg moves along the x-axis and is acted on by a force F. Figure shows how F varies with distance travelled, s.




The speed of the object at s = 0 is $10.00ms^{-1}$.
Determine
a) The speed of the object at s = 10 m **[Ans:** 11.5 $ms^{-1}$]
b) The kinetic energy of the object at s = 6.0 m **[Ans:** 150 $J$]

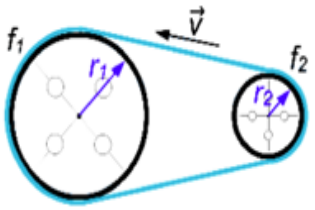
## 5.3 Power

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 **[Ans:** $2.38 \times 10^4$ $W$]
   b) the instantaneous power output of the engine at t = 12.0 s, just before the car stops accelerating **[Ans:** $4.77 \times 10^4$ $W$]
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). **[Ans:** 56452.1 $W$]
3. A car with power 100 kW produces a constant force F, of 500 N. Calculate the velocity of the car. **[Ans:** 200 $ms^{-1}$]

# 6 Circular Motion

## 6.1 Uniform Circular Motion

1. A 200 g of mass is moving with uniform angular velocity in a circle of radius 80 cm on a smooth horizontal surface. If the mass completes 10 revolutions in one second, calculate:
   a) the angular velocity **[Ans:** 62.8 $rad\ s^{-1}$]
   b) the linear velocity **[Ans:** 50.3 $rad\ s^{-1}$]
2. An object undergoes circular motion with uniform angular speed of 100 rpm. Calculate
   a) The period **[Ans:** 0.6 $s$]
   b) The frequency **[Ans:** 1.67 $s^{-1}$]
3. 2 wheels of a machine are connected by a transmission belt. The radius of the first wheel the radius of the second wheel.




The frequency of the bigger wheel equals 4.5 Hz.

What is the frequency of the smaller wheel? **[Ans:** 20.77 $Hz$]

## 6.2 Centripetal Force

1. 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?
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 $3.3ms^{-1}$. Determine the centripetal acceleration. **[Ans:** 785.5 $ms^{-2}$]
3. A ball of mass 0.150 kg is attached to one end of a string 0.6 m long. The ball makes 2.00 revolutions per second in a horizontal circle.

Calculate

a) The centripetal acceleration of the ball **[Ans:** 94.75 $ms^{-2}$]
b) The magnitude of the tension in the string **[Ans:** 14.21 $N$]

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.

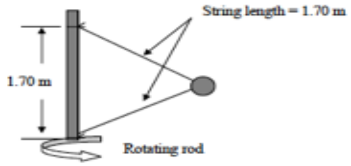
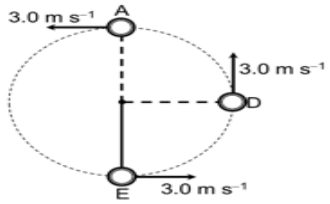


FIGURE 5

a) Draw free body diagram
b) Calculate tension in the lower string **[Ans:** 8.74 $N$]
c) Calculate net force on the ball **[Ans:** 37.88 $N$]
d) Calculate the speed of the ball **[Ans:** 6.45 $ms^{-1}$]

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 3.0$ms^{-1}$ as shown in the figure.




Determine the tension of the string at points A, D and E. **[Ans:** 32.77 $N$; 81.82 $N$; 131 $N$]

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 $v$ = 20$ms^{-1}$. The loop-the-loop has a radius of r = 20 m.

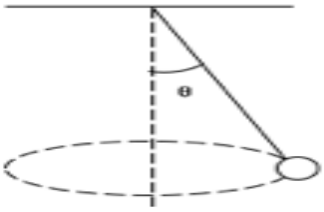
   a) What is the magnitude of the normal force on the car when it is at the bottom of the circle? **[Ans:** 14905 $N$]

   b) What is the magnitude of the normal force on the car when it is at the side of the circle? **[Ans:** 10000 $N$]

   c) What is the magnitude of the normal force on the car when it is at the top of the circle? **[Ans:** 5095 $N$]

   d) What is the minimum speed of the car so that it stays in contact with the track at the top of the loop? **[Ans:** 14 $ms^{-1}$]

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 **[Ans:** 787.8 $N$]
b) The speed of the bob **[Ans:** 0.865 $ms^{-1}$]
c) The period of the bob **[Ans:** 6.33 $s$]
d) The centripetal acceleration of the bob **[Ans:** 0.858 $ms^{-2}$]

# 7 Gravitation

## 7.1 Gravitational force and field strength

1. Calculate the net force on the moon due to the gravitational attraction of both the Earth and the Sun if,
   a) the Moon is between the Earth and the Sun (During solar eclipse) **[Ans:** $2.348 \times 10^{20}\ N$]
   b) They are at right angles to each other (first quarter Moon) **[Ans:** $4.77 \times 10^{20}\ N$]
2. A 200 kg object and a 500 kg object are separated by 4 m.
   a) Find the net gravitational force exerted by these objects on a 50.0 kg object placed midway between them **[Ans:** $2.5 \times 10^{-7}\ N$]
   b) At what position can the 50.0 kg object be placed so as to experience a net force of zero from the other two objects? **[Ans:** $1.55\ m\ from\ mass\ 1$]
3. What must the separation between a 5.2 kg particle and a 2.4 kg particle for their gravitational attraction to have a magnitude of $2.3 \times 10^{-12} N$ **[Ans:** $19.02\ m$]
4. Determine the magnitude of the gravitational field strength at a point
   a) 5000 km above the Earth's surface. **[Ans:** $3.08\ ms^{-2}$]
   b) On the Earth surface. **[Ans:** $9.80\ ms^{-2}$]
5. The gravitational field strength on the Earth's surface is $9.81 Nkg^{-1}$. Calculate:
   a) the gravitational field strength at a point C at distance 1.5R from the Earth's surface where R is the radius of the Earth **[Ans:** $1.57\ ms^{-2}$]
   b) the weight of a rock of mass 2.5 kg at point C **[Ans:** $3.93\ N$]

## 7.2 Gravitational Potential Energy

1. After the Sun exhausts its nuclear fuel, its ultimate fate may be to collapse to a white dwarf state. In this state, it would have approximately the same mass as it has now, but its radius would be equal to the radius of Earth. Calculate the gravitational potential energy associated with a 1.00 kg object at the surface of the white dwarf. **[Ans:** $-2.08 \times 10^{13}\ J$]

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.**[Ans:** $-1.62 \times 10^5\ J$]

   b) If all the gravitational potential energy lost is converted to kinetic energy, calculate the speed at which the probe hits the surface.**[Ans:** $56.92\ ms^{-1}$]

3. A space station of mass 400, 000 kg, orbits the earth at a height 36000 km above the Earth's surface. What are the gravitational potential energy of the space station? **[Ans:** $-3.766 \times 10^{12}\ J$]

## 7.3 Satellite motion in a circular orbit

1. A projectile is fired straight upward from the Earth's surface at the South Pole with an initial speed equal to one third the escape speed.

   a) Ignoring air resistance, determine how far from the center of the Earth the projectile travels before stopping momentarily. **[Ans:** $7.18 \times 10^6\ m$]

   b) What is the altitude of the projectile at this instant? **[Ans:** $8.00 \times 10^5\ m$]

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. **[Ans:** $-2.83 \times 10^{11}\ J$]

   b) the escape velocity of the rocket.**[Ans:** $11200\ ms^{-1}$]

3. A satellite travels at height of 150 km above the surface of the Earth. Determine

   a) Velocity of the satellite **[Ans:** $7815.5\ ms^{-1}$]

   b) The period of revolution of the satellite **[Ans:** $5249.72\ s$

4. A satellite is in a circular orbit around the Earth at an altitude of $2.80 \times 10^6$ . Find

   a) the period of the orbit **[Ans:** $8750\ s$

   b) the speed of the satellite **[Ans:** $6.59 \times 10^3\ ms^{-1}$]

   c) the acceleration of the satellite **[Ans:** $4.73\ ms^{-2}\ towards\ the\ Earth$]

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 $6.0 \times 10^{24}$ kg and $7.4 \times 10^{22}$ kg respectively. Calculate the radius of the Moon orbit. **[Ans:** $3.84 \times 10^8\ m$]

6. A satellite moves in circular orbit around Earth at a speed of $5103 ms^{-1}$. Determine,

   a) the satellite's altitude above the surface of Earth. **[Ans:** $9.6 \times 10^6\ m$]

b) the period of the satellite' s orbit. **[Ans:** $2.0 \times 10^4\ s$]

# 8 Rotation of Rigid Body

## 8.1 Rotational Kinematics

1. The angular displacement, $\theta$ of the wheel is given by

   $\theta = 5t^2 - t$

   where $\theta$ in radians and $t$ in seconds. The diameter of the wheel is 0.56 m. Determine,

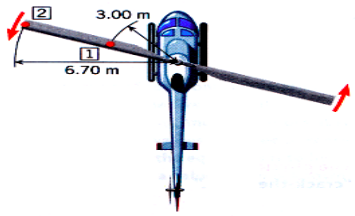
   a) the angle,$\theta$ in degree, at time 2.2 s and 4.8 s, **[Ans:** $1261^0;\ 6325.5^0$]

   b) the distance that a particle on the rim moves during that time interval **[Ans:** 24.6 $m$]

   c) the average angular velocity, in $rads^{-1}$ and in $rev\ min^{-1}$ (rpm), between 2.2 s and 4.8 s **[Ans:** 33.9 $rad\ s^{-1};\ 33.9\ rpm$]

   d) the instantaneous angular velocity at time 3.0 s.

2. A helicopter blade has an angular velocity of $w = 6.50revs^{-1}$ and an angular acceleration of $\alpha = 1.30revs^{-2}$.




   For points 1 and 2 on the blade in figure above, find the magnitudes of:

   a) the tangential velocities **[Ans:** 122.52 $ms^{-1};\ 273.63\ ms^{-1}$]

   b) the tangential acceleration **[Ans:** 24.5 $ms^{-2};\ 54.73\ ms^{-2}$]

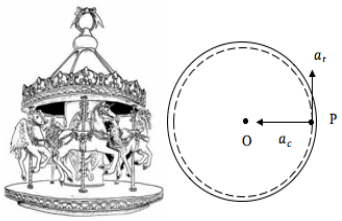
3. A disc that rotates about its axis accelerates uniformly from rest. After 2.0 s, its angular velocity is $5.0rads^{-1}$. An ant on the disc is at a distance of 8.0 cm from the center of the disc. Calculate:

   a) the tangential velocity of the ant when the angular velocity of the discs is $5.0rads^{-1}$ **[Ans:** 40.0 $cms^{-1}$]

   b) the angular acceleration of the disc **[Ans:** 2.5 $rads^{-2}$]

   c) the tangential acceleration of the ant. **[Ans:** 20.0 $cms^{-2}$]

4. Angular and linear velocities and accelerations. A carousel is $t = 0$ initially at rest. At $t = 0$ it is given a constant angular acceleration, $\alpha = 0.060 rads^{-2}$ which increases its angular velocity for 8.0 s.




At $t = 8.0s$, determine the magnitude of the following quantities:

a) The angular velocity of the carousel **[Ans:** 0.48 $rads^{-1}$]

b) The linear velocity of a child located 2.5 m from the centre, point P **[Ans:** 1.2 $ms^{-1}$]

c) The tangential acceleration of that child **[Ans:** 0.15 $ms^{-2}$]
d) The centripetal acceleration of the child **[Ans:** 0.576 $ms^{-2}$]
e) Total linear acceleration of the child **[Ans:** 0.595 $ms^{-2}$]

5. A wheel rotates with a constant angular acceleration of $3.5 rads^{-2}$. If the angular speed of the wheel is at $2.0 rads^{-1}$ at $t = 0$

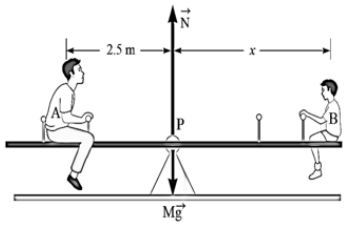
   a) Through what angular displacement does the wheel rotate in $t = 2.00s$? **[Ans:** 11 $rad$]

   b) Through how may revolutions has the wheel turned during this time? **[Ans:** 17.28 $revolution$]

   c) What is the angular speed of the wheel at $t = 2.00s$? **[Ans:** 9 $rads^{-1}$]

## 8.2 Equilibrium of a uniform rigid body

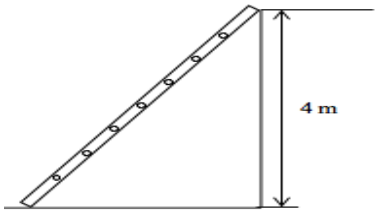
1. A board of mass M = 2.0 kg serves as a seesaw for two students (Aiman and Boniface), as shown in figure below. Aiman has a mass of 50 kg and sits 2.5 m from pivot point P.




a) At what distance x from the pivot point must Boniface of mass 45 kg, place himself to balance the seesaw? Assume the board is uniform and centred over the pivot. **[Ans:** 2.78 $m$]

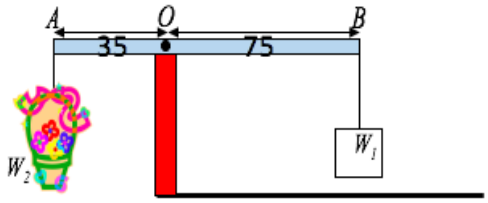
b) Calculate force exerted by pivot P. **[Ans:** 951.57 $N$]

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.
**[Ans:** 44.14 $N$; 125.73 $N$]

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.



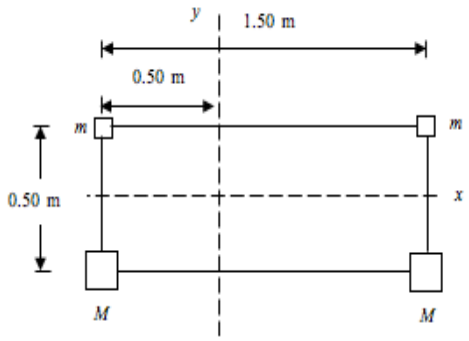

If the mass of the beam is 3.0 kg, calculate:

a) the weight, $W_1$ needed **[Ans:** 2.89 $N$]

b) the force exerted on the beam at point O **[Ans:** 55.3 $N$]

## 8.3 Rotational Dynamics

1. Assuming the objects are wired together by a very light rigid piece of wire. The array is rectangular and is split through the middle by the horizontal axis (x axis).




Calculate the moment of inertia of the array of point objects shown in figure below:

a) The vertical axis (y axis) **[Ans:** 6.625 $kg\ m^2$]

b) The horizontal axis (x axis) **[Ans:** 0.6625 $kg\ m^2$]

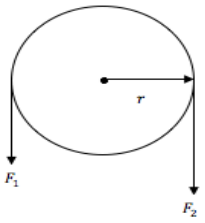
2. A 200 g coin is placed 10 cm from the center of the spinning disc. The mass of the spinning disc is 500 g and it has a radius of 20 cm. Determine

   a) the moment of inertia of the disc **[Ans:** 0.01 $kg\ m^2$]

   b) the moment of inertia of the coin **[Ans:** 0.002 $kg\ m^2$]

   c) the total moment of inertia of the system **[Ans:** 0.012 $kg\ m^2$]

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.



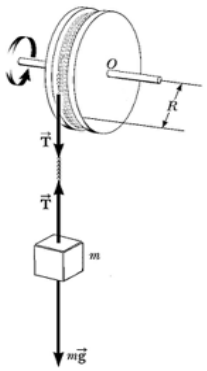

Calculate:

a) The net torque on the disk **[Ans:** $-1.692\ Nm$]

b) The magnitude of angular acceleration of the disk **[Ans:** $-5.22\ rad\ s^{-2}$]

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

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 **[Ans:** $7.36\ m\ s^{-2}$]

b) The angular acceleration of the pulley **[Ans:** $36.8\ rad\ s^{-2}$]

c) The tension in the string **[Ans:** $3.675\ N$]

d) The linear velocity of the object **[Ans:** $22.08\ ms^{-1}$]

## 8.4 Conservation of angular momentum

1. A 100 kg car moves on a circular track of radius 100 m with speed of $40ms^{-1}$ . Calculate the magnitude of its angular momentum relative to the center of the track. **[Ans:** $4 \times 10^6\ kg\ m^2\ s^{-1}$]
2. An ice skater rotates at $1.9revs^{-1}$ and has a moment of inertia of $1.33kgm^2$. Calculate the angular momentum. **[Ans:** $15.88\ kg\ m^2\ s^{-1}$]
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? **[Ans:** $6.25\ revs^{-1}$]

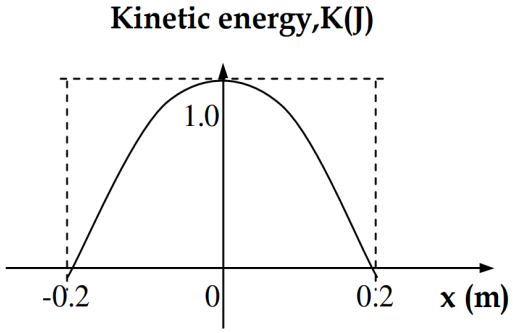
# 9 Simple Harmonic Motion

## 9.1 Kinematics of Simple Harmonic Motion

1. A particle is in simple harmonic motion in one dimension and moves according to the equation $x = 10\ sin\ (10\pi)\ t$ where $t$ is the time in seconds and $x$ is the displacement in $metres$. Determine
   a) the frequency, $f$. **[Ans:** $5hz$**]**
   b) the period, $T$. **[Ans:** $0.2s$**]**
   c) the angular frequency, $\omega$. **[Ans:** $10\pi rads^{-1}s$**]**
   d) the maximum displacement, $x_{max}$. **[Ans:** $10m$**]**
   e) the maximum velocity, $v_{max}$. **[Ans:** $100\pi ms^{-1}$**]**
   f) the maximum acceleration, $a_{max}$. **[Ans:** $1000\pi^2 ms^{-2}$**]**
   g) the displacement of the particle at time $t = 1.5s$. **[Ans:** $0m$**]**
   h) the velocity of the particle at time $t = 2.5s$. **[Ans:** $-100\pi ms^{-1}$**]**
   i) the acceleration of the particle at time $t = 3.5s$. **[Ans:** $0ms^{-2}$**]**
2. An object of mass $300g$ mass vibrates according to the equation $x = 38.0\ sin\ (6.50)t$, where $x$ is in metre and $t$ is in seconds. Determine the total energy and the potential energy and kinetic energy when $x = 9.0cm$ **[Ans:** $E_{total} = 0.92J$**;** $E_p = 5.1 \times 10^{-2}J;\ E_k = 0.86J$**]**
3. A mass $m$ at the end of a spring vibrates vertically with a frequency of $0.9\ Hz$. When an additional $1.2\ kg$ is attached to $m$, the frequency is $0.5\ Hz$. Calculate the value of m. **[Ans: 0.537** $kg$**]**
4. A $175\ g$ mass on a smooth surface is attached to a horizontal spring with a constant $8Nm^{-1}$. The mass is set to oscillate by pulling it $10cm$ from its equilibrium position and released. Calculate
   a) The period of the oscillation. **[Ans: 0.93**$s$**]**
   b) The maximum speed of mass. **[Ans: 0.68** $ms^{-1}$**]**
   c) The total energy of the system. **[0.04**$J$**]**

## 9.2 Graphs of simple harmonic motion

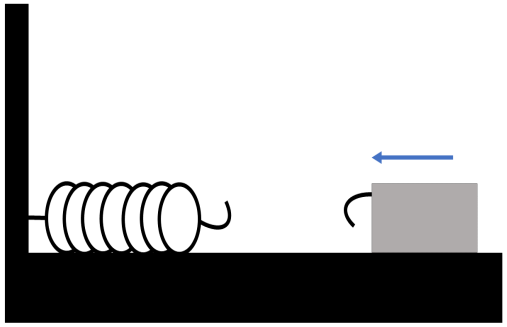
1. The figure below shows a particle of mass 4 kg is vibrating in simple harmonic motion (SHM). The graph for the kinetic energy, $K$ against displacement, $x$.




Calculate:
(a) the angular velocity. **[Ans: 3.54** $rads^{-1}$**]**

(b) the period. **[1.78**$s$**]**

2. The figure below shows a $0.5kg$ block slides at $3ms^{-1}$ on a frictionless horizontal surface. The block hits a spring and permanently hooked to it. The spring constant is $250Nm^{-1}$.

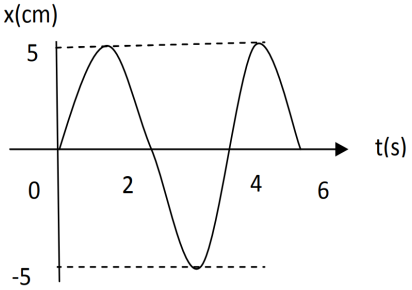


a) Calculate the maximum compression distance of the spring. **[Ans: 0.134** $m$**]**

b) How long is the spring in contact with the block before they come to the first instantaneous rest? **[Ans:** $7.03 \times 10^{-2}$**]**

c) On the same axes, sketch and label the graphs of kinetic energy, K and potential energy, $U$ of the block-spring system as a function of displacement, $x$ from their initial contact to their first maximum compression.
d) If oil is poured onto the horizontal surface, what will happen to the oscillation of the system?

3. Figure below shows a displacement-time graph of simple harmonic motion.




Determine
a) the amplitude. **[Ans: 5** $cm$**]**
b) the frequency. **[Ans: 0.25** $Hz$**]**
c) the angular velocity. **[Ans: 1.57** $rads^{-1}$**]**
d) the equation for the SHM

# 10 Mechanical and Sound Waves

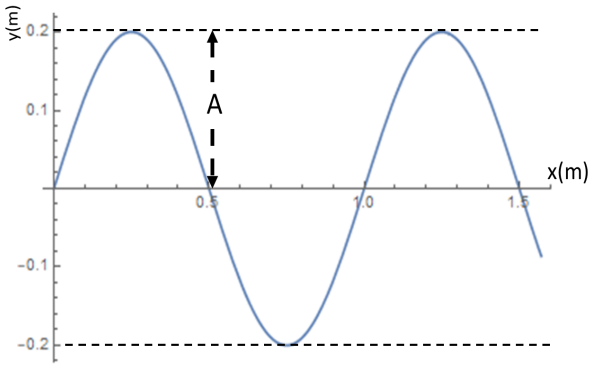
## 10.1 Properties of Waves

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.
**[Ans:** $A = 5cm;\ \omega = 2\pi rads^{-1};\ \lambda = 4cm;\ T = 1s;\ f = 1Hz;\ \vec{v} = +4ms^{-1}\hat{x}$**]**

2. Figure below shows the wave profile at time $t = 0s$ of a sinusoidal wave that travels in a straight line to the right at constant speed $10ms^{-1}$.




Write the wave equation that represents this wave.

3. A sinusoidal wave traveling in positive x direction has an amplitude of $15.0cm$, a wavelength of $40.0cm$ and a frequency of $8.0Hz$. Find the wave number $k$, period $T$, angular frequency, $\omega$ and speed, $v$ of the wave.
**[Ans:** $k = 15.71m^{-1};\ T = 0.125s;\ \omega = 50.27rad\ s^{-1};\ v = 3.2ms^{-1}$**]**

## 10.2 Superposition of Waves

1. The following two waves are superposed;

$$y_1(x,t) = 6\ sin(2t - 3x)$$
$$y_2(x,t) = 6\ sin(2t + 3x)$$

What type of wave is formed? Derive the equation of the resulting wave.
**[Ans: Stationary wave,** $y(x,t) = 12cos(3x)sin(2t)$**]**

## 10.3 Application of standing waves

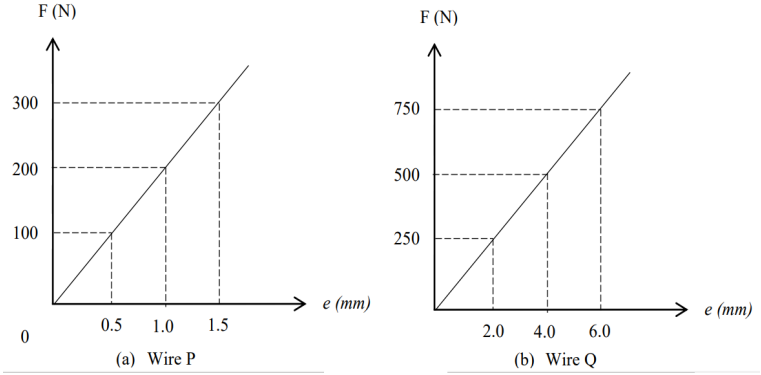
1. A closed pipe has a length of 60 cm. Resonance occurs and the vibrating air column in the pipe produced sound of frequency $425Hz$. Two antinodes are found in the air column and end correction is $1.0cm$. Determine
   a) the speed of sound in the air **[Ans:**$346ms^{-1}$**]**
   b) the fundamental frequency **[Ans:** $142Hz$**]**
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 **[Ans:** $0.2775m$**]**
   b) opened at both ends.**[Ans:** $0.555m$**]**
3. A stretched string of length $3.0m$ is plucked at the centre point to produce a fundamental frequency of $40Hz$.
   a) Calculate the velocity of the transverse wave along the string. **[Ans:** $240ms^{-1}$**]**
   b) At what position should the string be plucked so that the frequency of $80Hz$ is produced. **[Ans:** $0.75m$ **from one end]**
4. A $0.5kg$ object is hung at the end of a string of mass $72g$ and length $1.2m$. Calculate the speed of the wave propagation in the string when the system is disturbed. **[Ans:** $v = 9.04ms^{-1}$**]**

## 10.4 Doppler Effect

1. A person and a sound source which can produce sound of frequency $300Hz$ lie on the same horizontal straight line. Determine the frequency of the sound heard by the person if the source is stationary and the person moves at constant speed of $20ms^{-1}$
   a) towards the sound source **[Ans:318** $Hz$**]**
   b) away from the sound source **[Ans:282** $Hz$**]**
2. What frequency will be heard by a moving observer travelling at $25ms^{-1}$ towards a stationary siren that emits a sound of frequency 280 Hz if the velocity of sound in air, $v_{sound} = 343ms^{-1}$)
   **[Ans:** $f_o = 300Hz$**]**

# 11 Deformation of Solids

1. A wire with a length of $1m$, is lengthened by 0.6 mm when a load with a mass of $20kg$ is hung on it. If the diameter of the wire is $2mm$, calculate the
   a) Stress $[\delta = 6.25 \times 10^7 Pa]$
   b) Strain $[\epsilon = 6 \times 10^{-4}]$
   c) Young's Modulus $[Y = 1.04 \times 10^{11} Pa]$
   d) Force Constant of the wire $[k = 3.27 \times 10^5 N\ m^{-1}]$
2. An object P of mass $0.5kg$ hangs on a vertical tungsten wire of diameter $0.22mm$ and length of $1.0m$. Hanging from the bottom of P is a copper wire of diameter $0.5mm$ and length of $1.5m$ that supports an object Q of mass $0.35kg$. **Assume that the elastic limit of the wires is not exceeded and both wires are massless.** Given $Y_{tungsten} = 3.60 \times 10^{11}\ Pa$, $Y_{copper} = 1.2 \times 10^{11} Pa$; $g = 9.81 ms^{-1}$.Determine
   a) The tension in both wires **[Ans:** $3.43N$**;** $8.34N$**]**
   b) The total strain energy of the system **[Ans:** $2.92 \times 10^{-3} J$**]**
3. The graph of force against elongation for wires X and Y are as shown below. The wires have the same original length and the same cross-sectional area of 4.0 $mm^2$.



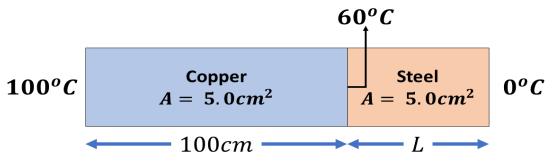

   a) Calculate the work done to extend wires P and Q by $1.0mm$. Hence state which wire is more rigid. **[Ans:** $0.1J$**;** $0.063J$**]**
   b) From the graphs above, deduce the ratio of Young's modulus of wire P to the Young's modulus of wire Q.

4. A wire X has length 100$cm$ and diameter 2.0$mm$. A wire Y has length 200$cm$ and diameter 4.0$mm$. Forces of same magnitude pull both wires and the extensions of X and Y are produced are 0.10 $mm$ and 0.04 $mm$ respectively. Determine the ratio of the Young's modulus for wire X to that for wire Y. **[Ans: 0.8]**

# 12 Heat Conduction and Thermal Expansion

## 12.1 Heat conduction

1. Glass has a thermal conductivity of 0.8 $Wm^{-1}K^{-1}$ . A glass plate has a cross-sectional area of 2.0 $m^2$ and thickness of 4.0$mm$. if the temperature different between two surface of the glass plate is 15 $^oC$, calculate the rate of heat flow through the glass plate. **[]Ans: 6 x 103 W]**
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 **[Ans: 18.2 cm]**

b) The rate of heat flow through both rods. **[Ans: 7.6 W]**

## 12.2 Thermal Expansion

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? **[Ans: 436.67$^oC$]**
   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? **[Ans: 2099 $^oC$]**
   c) Would this latter process work? Explain?
2. The 70-liter (L) steel gas tank of a car is filled to the top with gasoline at 20 $^oC$. The car sits in the Sun and the tank reaches a temperature of 40 $^oC$ How much gasoline do you

expect to overflow from the tank? ($\alpha_{steel} = 12 \times 10^{-6o} C^{-1}$, $\gamma_{gasoline} = 950 \times 10^{-6o} C^{-1}$) **[Ans: 1.28$L$]**

3. A pendulum clock is made (at 25 $^oC$) by supporting a bob at the very end of a 1.0$m$ long steel wire. Determine its period. **[Ans: 2.006$s$]**
   Now find its period on a winter's day when the heater goes out and the temperature drops to -5$^oC$. Did the clock run fast or slow that day? ($\alpha_{steel} = 12 \times 10^{-6} K^{-1}$)
   **[Ans:** 2.0057$s$**]**

# 13 Gas Laws and Kinetic Theory

## 13.1 Ideal Gas Equation

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 **[Ans: 0.1**$mol$**]**
   b) the final temperature of the gas **[Ans: 545.67** $K$**]**
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? **[Ans: The temperature in B is 3 times the temp in A.]**

## 13.2 Kinetic Theory of Gases

1. The density of oxygen gas at STP is 1.43 $kgm^{-3}$. Estimate the rms speed of oxygen gas molecules at STP. Assume that the gas behaves as an ideal gas. **[Ans : 461** $ms^{-1}$**]**
2. The molar mass of oxygen is 32 $gmol^{-1}$. At 370 $K$, find
   a) the root mean square speed of the oxygen molecules, **[Ans: 537** $ms^{-1}$**]**
   b) the internal energy of 5 moles of oxygen. **[Ans: 7686.75** $J$**]**
3. The initial temperature of a gas is $30^oC$. If the root mean square (rms) speed of the gas molecules is reduce by 3%, find the final temperature of this gas. **[Ans: 285**$K$**]**

## 13.3 Molecular kinetic energy and internal energy

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. **[Ans.: 328 K]**
2. An ideal gas has 6 degrees of freedom at 40 $^oC$. Calculate
   a) the kinetic energy of the gas molecule [**Ans : 1.30 x 10-20** $J$**]**

b) the total energy in one mole of gas. **[Ans : 7826** $J$ **]**

3. A container is filled with 4 moles of hydrogen gas at 25 $^oC$. Calculate:
   a) Translational kinetic energy of hydrogen molecules **[Ans :** $6.17 \times 10^{-21} J$**]**
   b) Total translational kinetic energy of hydrogen gas **[Ans :** $14.86 \times 10^3 J$**]**
   c) Average kinetic energy of hydrogen gas. **[Ans :** $24.79 \times 10^3 J$**]**
   d) Internal energy of hydrogen gas. **[Ans :** $24.79 \times 10^3 J$**]**
4. A vessel contains monoatomic neon gas of mass 10g at temperature 20 $^oC$. Determine the internal energy of the gas. Assume that the gas behaves like an ideal gas. ($N_A$ = $6.02x1023mol^{-1}$ ; Relative atomic mass of neon = 40) **[Ans: 916.3** $J$**]**

# 14 Thermodynamics

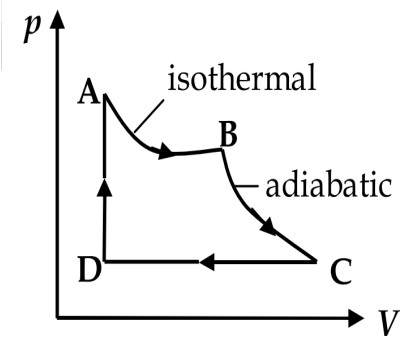
## 14.1 First Law of Thermodynamics

In each of the following situations, calculate the change in the internal energy of the system.

1. A system absorbs 2090 J of heat and the same time does 400 J of work. [$\Delta U = 1.69kJ$]
2. A system absorbs 1255 J of heat and at the same time 420 J of work is done on it. [$\Delta U = 1.675kJ$]
3. 5020 J of heat is removed from a gas held at constant volume. [$\Delta U = -5.02kJ$]
4. An ideal gas releases 2.85 kJ of heat after being compressed by 0.15 kJ of work. Determine the change in internal energy of the gas. [**Ans:** $\Delta U = -2.70kJ$]

## 14.2 Thermodynamics processes

1.




A gas system undergoes thermodynamic changes as shown in the figure.

If $Q$ is the heat transferred, $W$ is the work done and $\Delta U$ is the change in internal energy, then complete the table below with signs (+), (−) or 0 for values of $Q, W, \Delta U$ which are obtained in the processes AB, BC, CD and DA.

| | Q | W | $\Delta U$ |
|---|---|---|---|
| AB | | | |
| BC | | | |
| CD | | | |
| DA | | | |

## 14.3 Thermodynamics work

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? **[Ans: 0 J]**

b) Find the amount of heat absorbed or lost by the gas. **[Ans: 30 J]**

2. Consider the following two-step process. Heat is allowed to flow out of an ideal gas at constant volume so that its pressure drops from $2.2atm$ to $1.4atm$. Then the gas expands at constant pressure, from a volume of $6.8litres$ to $9.3litres$, where the temperature reaches its original value. Calculate

   a) the total work done by the gas in the process. **[Ans:** $W = 3.5 \times 10^2 J$**]**

   b) the change in internal energy of the gas in the process. **[Ans:**$\Delta U = 0J$**]**

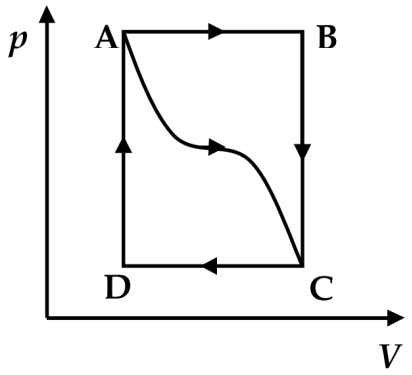
   c) the total heat flow into or out of the gas. **[Ans:** $Q = 3.5 \times 10^2 J$**]**

3. In an engine, an almost ideal gas is compressed adiabatically to half its volume. In doing so, $1850J$ of work is done on the gas.

   a) Calculate the heat flows into or out of the gas. **[Ans:** $0J$**]**

   b) Calculate the change in internal energy of the gas. **[Ans:** $1850J$**]**

   c) Does its temperature rise or fall?

4. 


In the given figure, the change in internal energy of a system that is taken from A to C is +800$J$. The work done along path ABC is +500$J$.

a) Calculate the energy that must be added to the system by heat as it goes from A through B to C. **[Ans:** $Q = 1300J$**]**
b) If the pressure at point A is five times that of point C, determine the work done in going from C to D. **[Ans:** $W = -100J$**]**
c) Calculate the energy exchanged with the surroundings by heat as the cycle goes from C to A along the CDA path **[Ans:** $Q = -900J$**]**
d) If the change in internal energy in going from point D to point A is +500$J$, calculate the energy that must be added to the system as it goes from point C to point D. **[Ans:** $W = -1400J$**]**

# Bibliography