Physics Semester 1 Speedrun 2024 WR

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1 Introduction

I hate physics, you do too. I cannot remember the formulas, you do too. It is my God given rights to make this pdf, so you should read it too. There are 6 topics for physics semester 1, 2 from term 3 and 3 from term 2.

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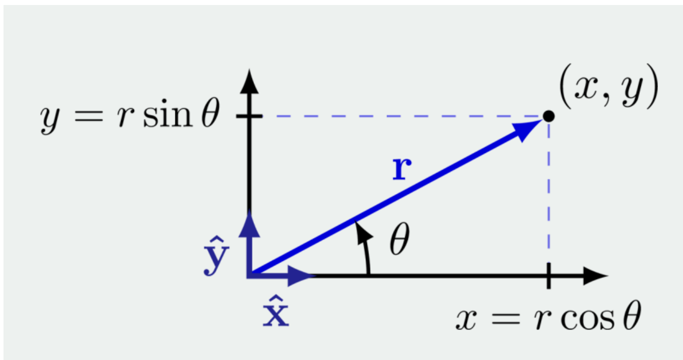
3 Vectors

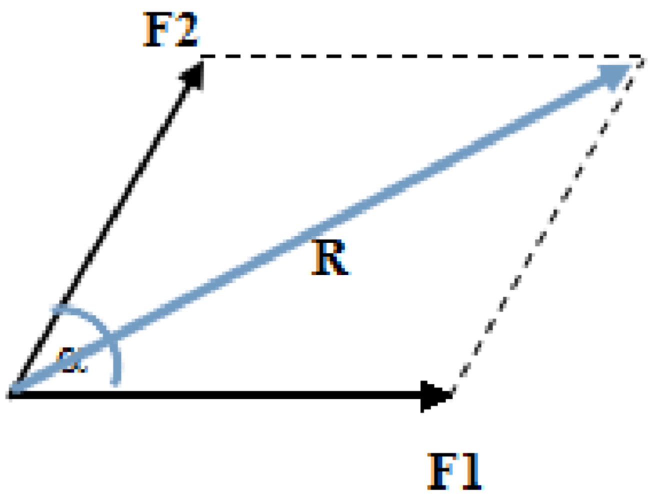


$$cos\theta = \frac{x}{r} \longleftrightarrow r_x = rcos\theta$$

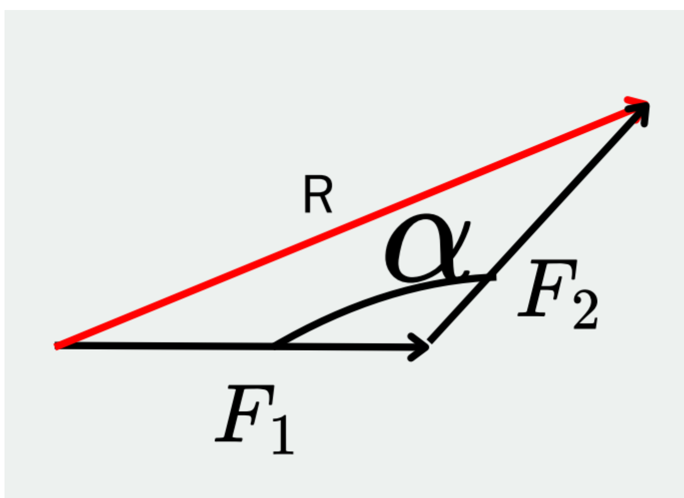
$$sin\theta = \frac{y}{r} \longleftrightarrow r_y = rsin\theta$$

$$\frac{sin\theta}{cos\theta} = \frac{\frac{y}{r}}{\frac{x}{r}} \longleftrightarrow tan\theta = \frac{y}{x}$$

$$R = \sqrt{x^2 + y^2}$$

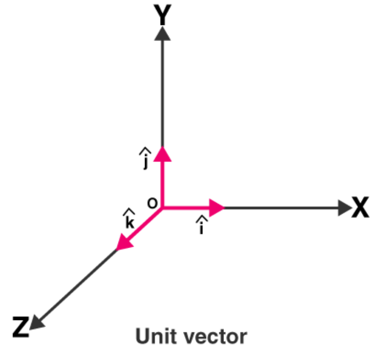


$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 * cos\theta}$$



$$R = \sqrt{F_1^2 + F_2^2 - 2F_1F_2 * cos\theta}$$

3.1 Dot Product



The multiplication of the same vector will result in 1, but the multiplication of differnet vectors will result in 0.

$$\hat{i}.\hat{i} = 1$$
$$\hat{k}.\hat{i} = 0$$

4 Recap: SUVAT Equations

$$v = u + at$$
$$s^2 = u.t + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

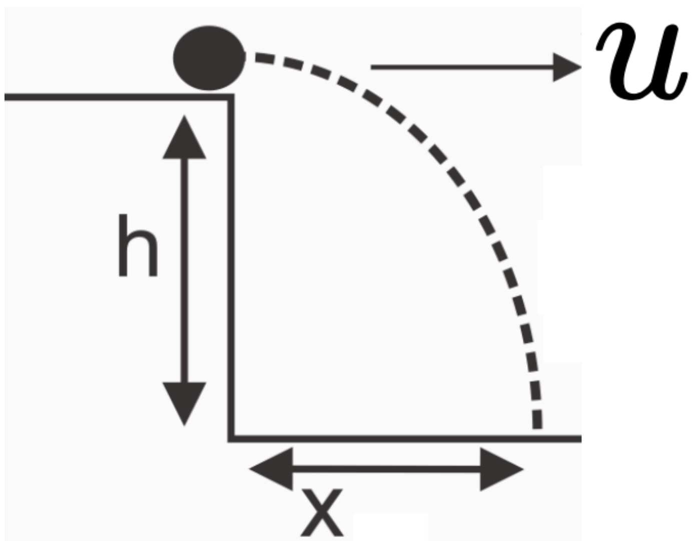
Where the components and SI units are,

u = initial velocity (m/s)
v = final velocity (m/s)
s = distance (m)
t = time (s)

a = acceleration (m/s^2)

5 Parabolic Motion

5.1 Horizontal Parabolic Motion

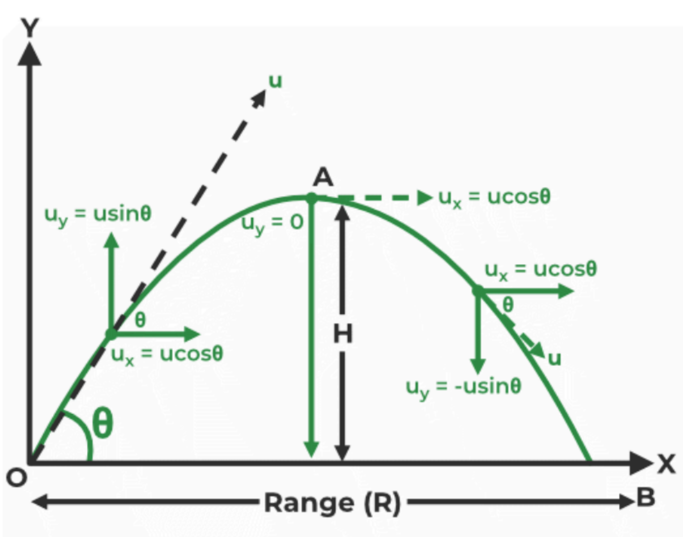


$$t = \sqrt{\frac{2g}{h}}$$
$$s = u.t$$

Note, this is only used in horizontal parabolic motion. The components and units are,

g = gravity (m/s^2), commonly 10 m/s^2 if not given
h = height (m)

5.2 Normal Parabolic Motion ($-ax^2 + bx + c$)



$$t_{max} = \frac{u * sin\theta}{g}$$

Where this is the maximum time from start to the maximum height (Point A).

$$t_{total} = 2 * t_{max} \longleftrightarrow \frac{2 * u * sin\theta}{g}$$

Where this is the total time from start to finish without interruption.

$$y_{max} = \frac{u^2 * sin^2\theta}{2g}$$

Maximum height of any object in parabolic motion (Point A).

$$x_{max} = \frac{u^2 sin2\theta}{g} \longleftrightarrow x_{max} = \frac{u^2 * 2sin\theta cos\theta}{g}$$

Maximum distance in the x axis, do note the right arrow is just the proofing/simplification of the formula.

5.3 SUVAT Equations in Parabolic Motion

5.3.1 To find the x,y distance in a certain time

$$x = (ucos\theta)t$$

$$y = (usin\theta)t - \frac{1}{2}gt^2$$

5.3.2 Velocity of Horizontal and Vertical Components

$$V_x = ucos\theta$$

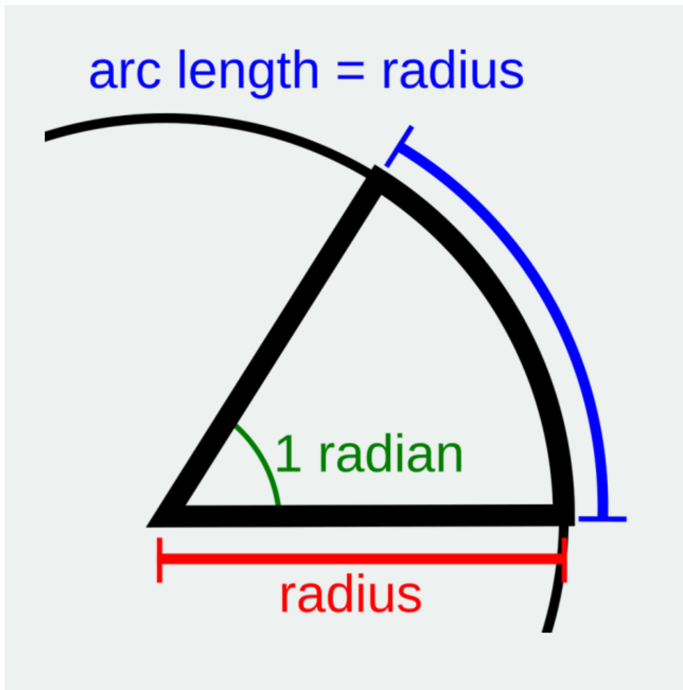
$$V_y = usin\theta - gt$$

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

$$V_y^2 = (usin\theta)^2 - 2gh$$

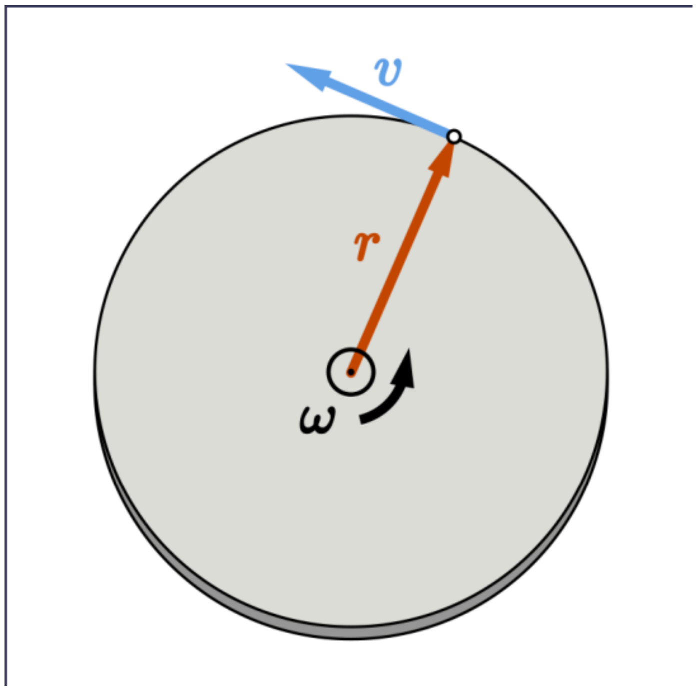
6 Rotational Motion

6.1 Radians



$$1loop = 2\pi rad$$
$$1rad = \frac{180^\circ}{\pi} = 57.3^\circ$$
$$rad = (\frac{\pi}{180^\circ}) * \theta$$

6.2 Angular Velocity



$$\omega = \frac{\Delta\theta}{\Delta t} \longleftrightarrow \frac{\theta_2 - \theta_1}{t_2 - t_1}$$

Where the components and the units are,
ω = angular velocity (rad/s)
$\Delta\theta$ = change in angle (radian)

6.3 Relationship of Motion and Circular Motion

$$v = \frac{\Delta s}{\Delta t}$$

s can be found using this formula,

$$s = \theta r$$

$$v = \frac{\Delta s}{\Delta t} \longleftrightarrow \frac{\Delta(\theta r)}{\Delta t} \longleftrightarrow r\frac{\Delta\theta}{\Delta t}$$

Remember the formula for angular velocity?

$$\omega = \frac{\Delta\omega}{\Delta t}$$

$$v = r\omega$$

The components and units are,

s = distance (m)
θ = angle
v = tangential velocity (m/s)
r = radius (m)

Frequency, the amount of rotations that can happen in 1 second.

$$f = \frac{n}{t} \longleftrightarrow \frac{\omega}{2\pi}$$

Thus it can be concluded that,

$$\omega = 2\pi f$$

$$v = 2\pi r f$$

Period, the time needed to complete 1 full rotation.

$$T = \frac{t}{n} \longleftrightarrow \frac{2\pi}{\omega}$$

$$\omega = \frac{2\pi}{T}$$

Thus it can be concluded that, the relation of frequency and period are,

$$T = \frac{1}{f}$$

$$f = \frac{1}{T}$$

The components and SI units are,

f = Frequency, the amount of rotations that can happen in 1 second (Hz)
n = The number of revolutions/cycles completed
T = Period, the time needed to complete 1 full rotation (s)

To explain why t can be instantly made into 2π, it is because 2π is 360°, so it is the time to complete 360°.

6.4 Centripetal Force

The formula for angular acceleration.

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

The formula for force in general

$$F = ma$$

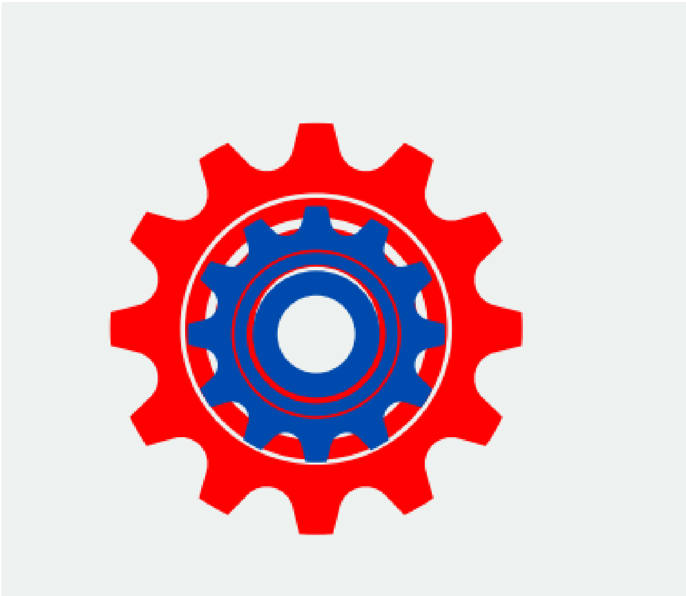
Where, to find the centripetal force

$$F = ma_s \longleftrightarrow \frac{mv^2}{r}$$

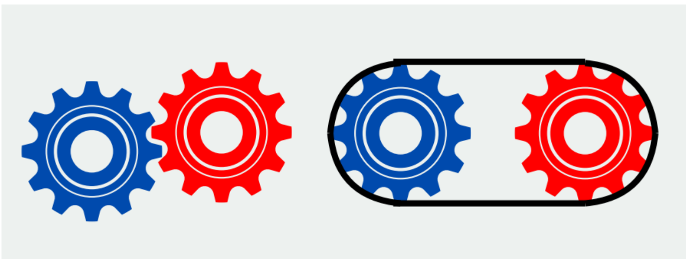
The components and SI units are,

a_s = angular acceleration (m/s^2)
F = force (n)
m = mass (kg)

6.5 Torque



$$\omega_a = \omega_b$$
$$\frac{v_a}{r_a} = \frac{v_b}{r_b}$$



$$v_a = v_b$$

$$\omega_a * r_a = \omega_b * r_b$$

7 Force and Motion

7.1 Newton's Laws of Motion

7.1.1 Newton's First Law, Law of Inertia

An object will stay still or keep moving in the same direction and speed unless a force makes it change. An example is the golf ball will remain on the ground until the golfer hits it.

$$\Sigma F = 0$$

7.1.2 Newton's Second Law, Law of Acceleration

The harder you push something, the faster it moves; the heavier it is, the harder you need to push to make it move. An example would be The car accelerates forward since the force due to its engine is greater than the friction on the road.

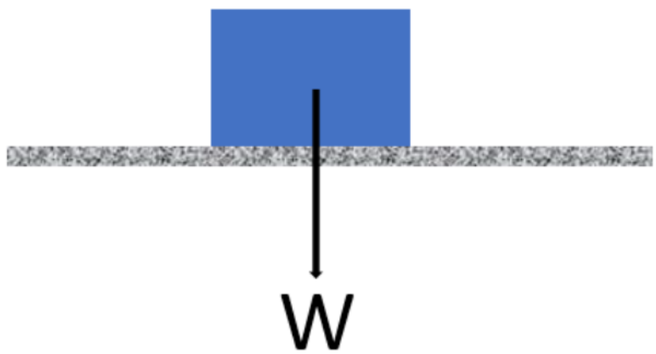
$$\Sigma F = ma$$

7.1.3 Newton's Third Law, Law of Action and Reaction

Every action force has a reaction force and an opposite in direction. An example is when a balloon deflates, the air pushes out, and the balloon moves in the opposite direction.

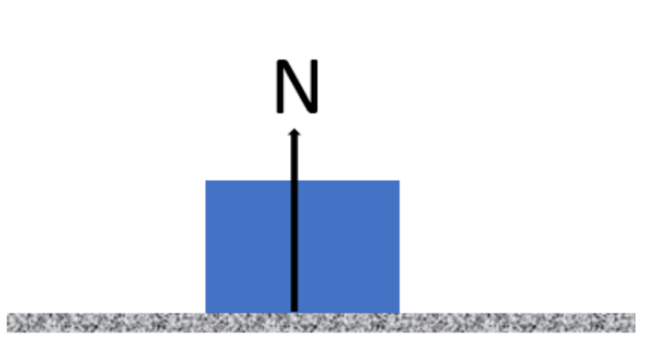
$$F_{action} = -F_{reaction}$$

7.2 Weight Force



$$W = mg$$

7.3 Normal Force



The normal force is the force that acts on an object when it rests on a surface. It prevents the object from falling through the surface. Formula depends on direction.

7.4 Friction Force

Friction Force works only in rough plane/surface. This force works in the opposite direction to the direction of motion of the object

7.4.1 Kinetic Friction Force

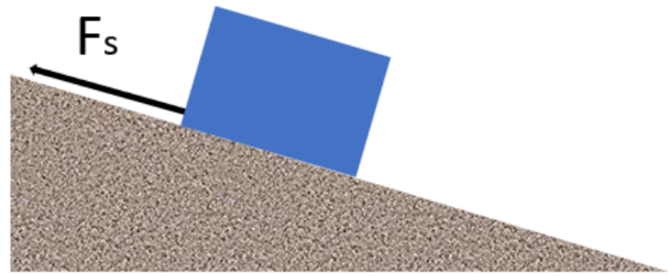
The frictional force that resists the motion of two surfaces sliding past each other once they are already in motion

$$F_k = \mu_k * N$$

Where,

F_k = kinetic friction force (N)
μ_k = coefficient of kinetic friction (usually given, if not assume 0.6)
N = normal Force (N)

7.4.2 Static Friction Force



The frictional force that resists the initiation of motion between two surfaces that are in contact but not yet moving

$$F_s = \mu_s * N$$

Where,

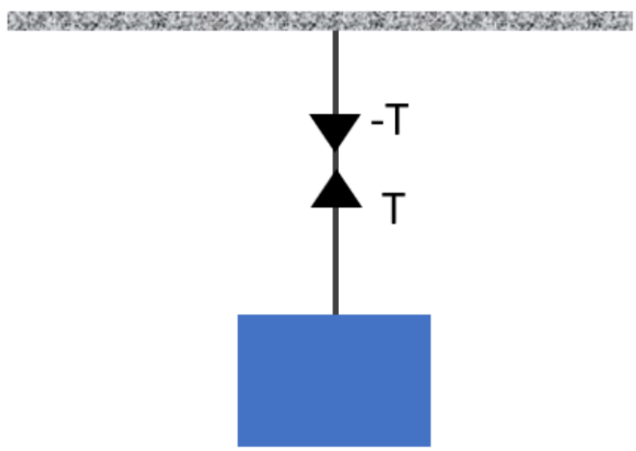
F_s = static friction force (N)
μ_s = coefficient of static friction (usually given, if not assume 0,4)

7.4.3 Friction Scenarios

$F_{applied}, F_{static} = 0$, no motion because no applied force, hence no static force is acted.
$F_{acted} < F_{static}$, no motion because the applied force is less than the static friction force.
$F_{applied} = F_{static}$, no motion because the applied force and the static force is the same, any more applied force.
$F_{applied} > F_{static}$, motion starts because applied force is larger than the static force.

$F_{applied}, F_{kinetic} = 0$, no motion because no applied force so no kinetic force is acted upon.
$F_{applied} < F_{static}$, kinetic friction is resisting the applied force of the object, object continues to move.
$F_{applied} = F_{kinetic}$, both are in equilibrium, object goes on constant speed.
$F_{applied} > F_{kinetic}$, object goes faster/ is in acceleration.

7.4.4 Tension Force



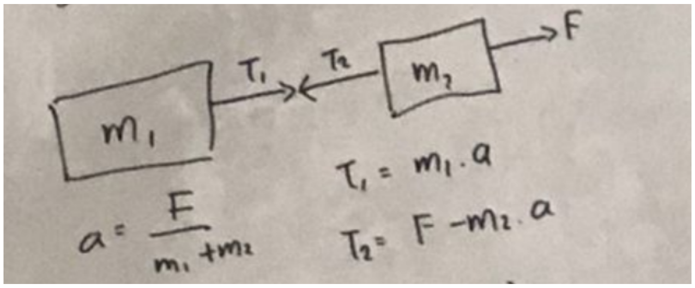
Tension force works as action-reaction force along an object such as a string, rope, chain, rod.

7.4.5 Forces with Angles

$$F_y = F * sin\theta$$
$$F_x = F * cos\theta$$

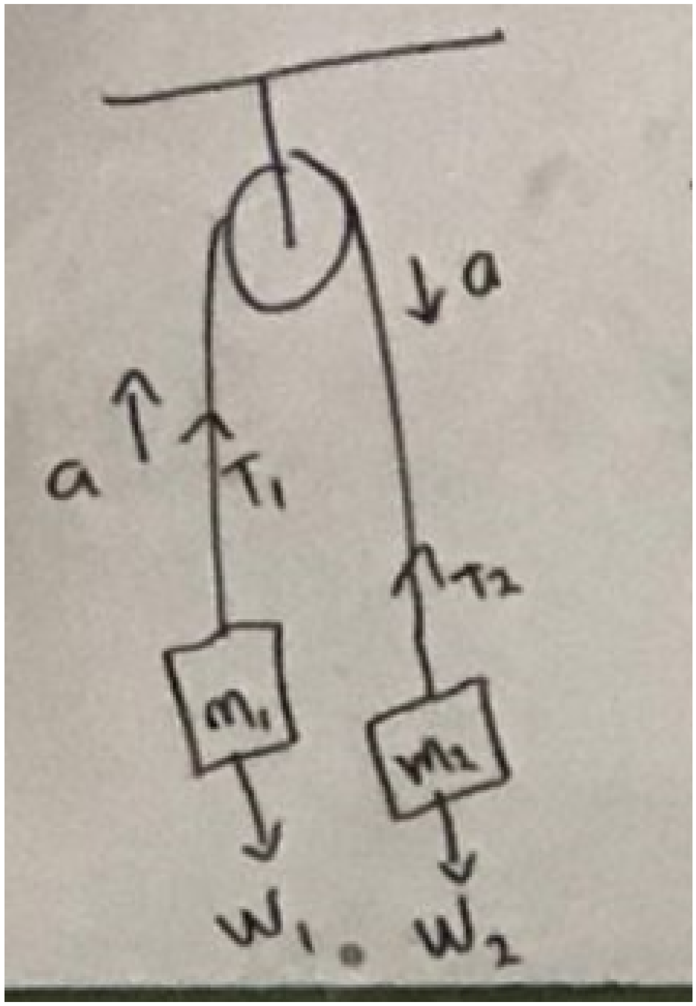
7.5 Pulley

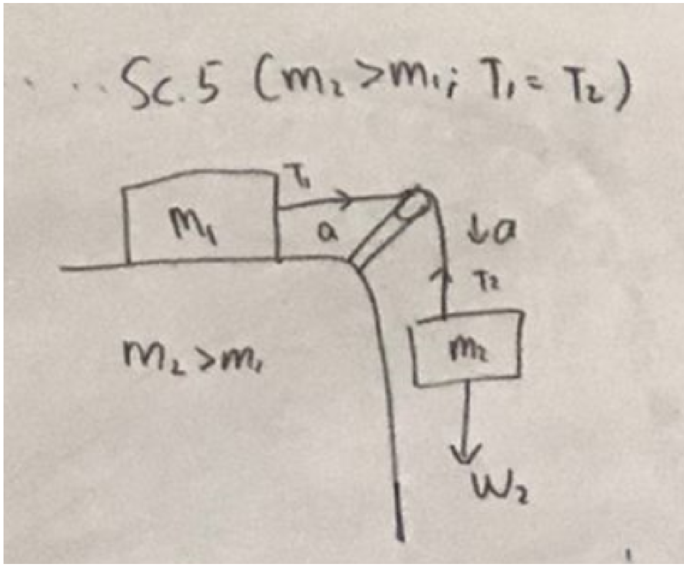
I hate this, hence I am helping you with this



In this scenario, the formula is

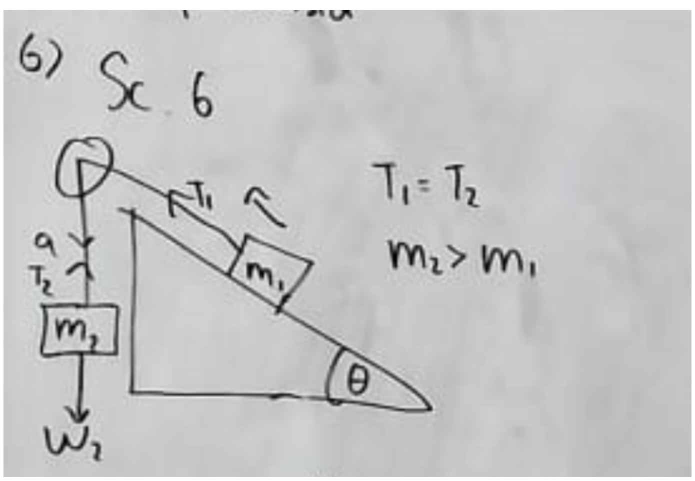
$$a = \frac{F}{m_1 + m_2}$$


a
a
T1
T2
m1
m2
W1
W2



Where the m_2 is larger than the m_1, the formula is this

$$a = \frac{m_2 - m_1}{m_2 + m_1} * g$$



Where $m_2 > m_1$, as most questions have the m_2 being larger than the other. Formula if the pulley have a mass is, (in this case the pulley don't have a mass)

$$a = \frac{m_2 - m_1 sin\theta}{m_2 + m_1}$$

But if the pulley have a mass, there is another formula

$$a = \frac{m_2 - m_1}{m_2 + m_1 + \frac{1}{2}M}$$

Where M is the mass of the pulley. Do note the $\frac{1}{2}$ is just a place holder for the I, if it's not given don't put $\frac{1}{2}$ but if the I is something like $\frac{2}{3}$ put that instead.

8 Work and Energy

8.1 Work

Work is the force acted upon a object in accordance to the distance.

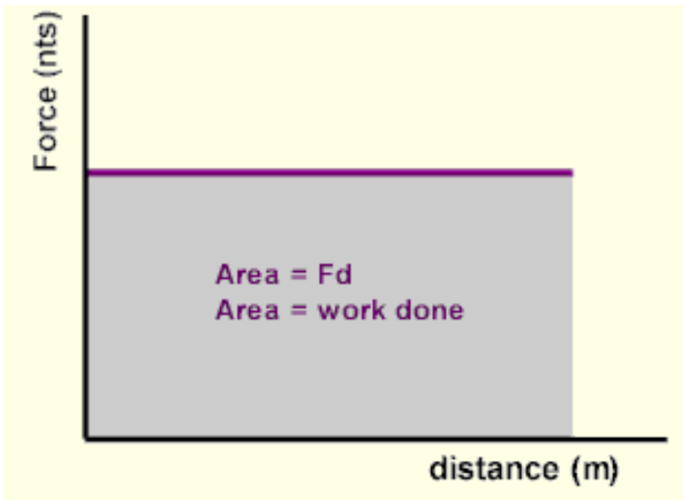
$$W = F * s$$

$$\Sigma W = W_1 + W_2 + W_3 + ... + W_n$$

$$W = F * s * cos\theta$$

The components and SI units are,
W = work (Nm, J)
F = force (N)
s = distance (m)

8.1.1 Work Graph



8.2 Energy

Energy is the ability to do work. Yeah that's it.

8.2.1 Kinetic Energy

The energy when the object changes velocity. The faster the object is, the larger the kinetic energy.

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

The components and SI Units are,

KE/E_k = kinetic energy (J)
m = mass (kg)
v = velocity (m/s)

8.2.2 Potential Energy

Potential energy is the energy an object has because of its position or condition. It's like "stored energy" that can be used later.

$$PE/E_p = mgh$$

The components and SI Units are,

PE/E_p = potential energy (J)
m = mass (kg)
g = gravity (m/s^2), assume 10 m/s^2 until given
h = height (m)

8.2.3 Relationship of Work and Energy

The relationship between work and energy is that work is the process of transferring energy from one object to another or converting energy from one form to another. They are closely linked because work done on an object changes its energy. If you push a stationary object, work done on it increases its kinetic energy.

$$W = \Delta KE/E_k \longleftrightarrow \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$$

The work-kinetic energy theorem, the components and si units are as of follows,

W = work (J)
$\Delta KE/E_k$ = change of kinetic energy (J)

The work-potential energy theorem, when you do work against a force, like lifting an object against gravity, the work you do becomes stored as potential energy. Conversely, when potential energy is released (like a ball falling), that energy can do work.

$$W = \Delta PE \longleftrightarrow m_1gh_1 - m_2gh_2$$

The component and SI units are as follows,
ΔPE = Change of Potential Energy (J)

8.2.4 Conservative Law of Mechanics

Albert Einstein, Jewish German born Theoretical physicist famously said, "energy cannot be created or destroyed, it can only be changed from one form to another.". This is the basis of this conservative law of mechanical energy, where potential energy to kinetic energy, to potential, and so forth.
Mechanical energy is the energy an object has because of its motion or position. It is the sum of kinetic energy (energy of motion) and potential energy (energy of position or stored energy).

$$ME = KE + PE \longleftrightarrow \frac{1}{2}mv^2 + mgh$$

Mechanical Energy on all points are always the same, hence it can be said that

$$ME_1 = ME_2$$

$$KE_1 + PE_1 = KE_2 + PE_2 \longleftrightarrow \frac{1}{2}mv^2 + mgh = \frac{1}{2}mv^2 + mgh$$

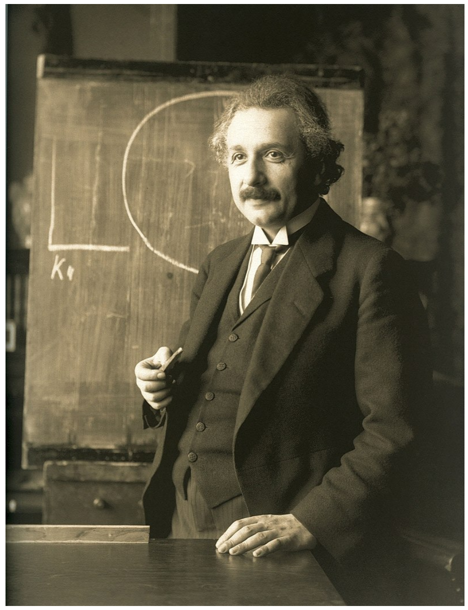


Figure 1: Einstein in a Vienna Lecture 1921

Do remember that, at first there is no kinetic energy but full of potential energy, once the work has been acted upon the object, potential energy will turn into kinetic energy until done.

$$PE = KE \longleftrightarrow \frac{1}{2}mv^2 = mgh$$

8.3 Power

Power is defined as the rate of energy transferring.

$$P = \frac{E}{t} \longleftrightarrow \frac{\Delta W}{t} \longleftrightarrow Fv$$

The components and SI units are,
P = power (W)
E = energy (potential/kinetic)

9 Momentum and Impulse

9.1 Momentum

Momentum is a measure of how much motion an object has, depending on its mass and velocity. It shows how difficult it is to stop a moving object.

$$p = mv$$

$$\Delta p = m\Delta v$$

The component are as follows,

p = momentum (Ns, kgm/s)
m = mass (kg)
v = velocity (m/s)

9.2 Impulse

Impulse is the change in an object's momentum, caused by a force acting over a period of time. It explains how momentum is transferred or changed.

$$I = Ft$$

The components and SI units are,

I = impulse (Ns)
F = force (N)
t = time (s)

9.3 Relationship Between Impulse and Momentum

Impulse is the cause, and momentum is the effect. When you apply a force over time, it changes an object's momentum.

$$I = \Delta p$$

The smaller the contact time required, the greater the contact force experienced

$$F = \frac{\Delta p}{\Delta t} \longleftrightarrow \frac{I}{\Delta t}$$

9.4 Conservative Law of Momentum

The Law of Conservation of Momentum states that the total momentum of a system remains constant if no external forces act on it. In other words, the momentum before an interaction (like a collision) is equal to the momentum after the interaction.

$$P_{final} = P_{initial} \longleftrightarrow m_1 v_1 = m_2 v_2$$

Optionally, if there are more than 2 components,

$$P_{final} = P_{initial} \longleftrightarrow m_1 v_1 = m_2 v_2 + m_3 v_3$$

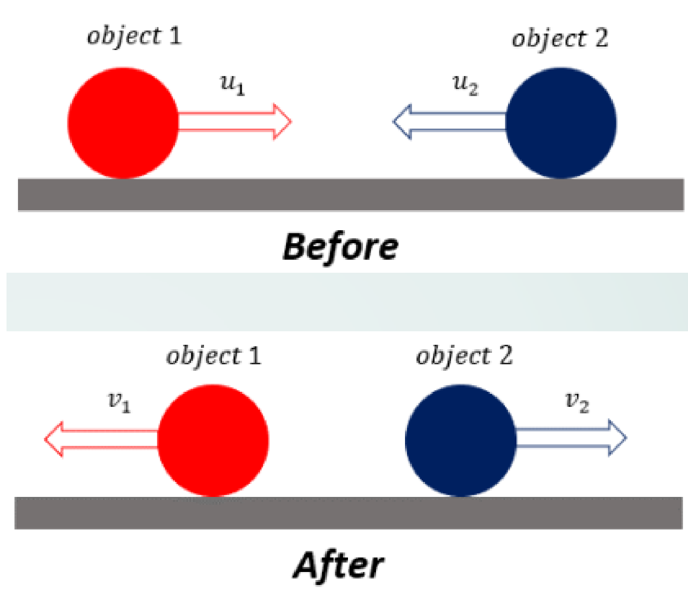
The components and SI units are,

9.5 Collision

A collision is an event where two or more objects come into contact and exert forces on each other in a very short time. Collisions are studied to understand how momentum and energy are transferred between objects. Total kinetic energy before collision same as total kinetic energy after collision.

9.5.1 Elastic Collision

In an elastic collision, both momentum and kinetic energy are conserved.



$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

The components and SI units of these are,

m_1 = mass of the first object (kg)
m_2 = mass of the second object (kg)
u_1 = initial velocity of the first object (m/s)
u_2 = initial velocity of the second object (m/s)
v_1 = final velocity of the first object (m/s)

v_2 = final velocity of the second object (m/s)

9.5.2 Inelastic Collision

In an inelastic collision, momentum is conserved, but kinetic energy is not conserved. Some kinetic energy is converted into other forms of energy, like heat, sound, or deformation. Formula is the same as the perfect elastic collision.

9.5.3 Perfect Inelastic Collision

A perfectly inelastic collision is the most extreme case of inelastic collisions, where the objects stick together after the collision.

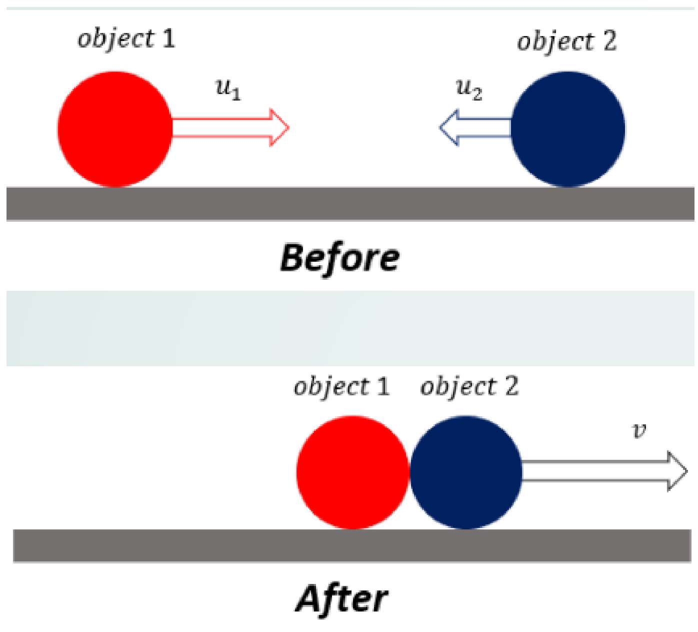
$$m_1u_1 + m_2u_2 = (m_1 + m_2)v$$

9.6 Determining the Type of Collision

$$e = \frac{-(v_2 - v_1)}{u_2 - u_1}$$

The components and SI units are,

e = restitution coefficient
u_1 = initial velocity of first object (m/s)



u_2 = initial velocity of second object (m/s)
v_1 = final velocity of first object (m/s)
v_2 = final velocity of second object (m/s)

To determine the type of collision, we use the restitution coefficient, where

$e = 1$, it is a perfect elastic collision
$0 < e < 1$, it is a inelastic collision
$e = 0$, its a perfect inelastic collision

9.7 Bouncing Height

This applies towards inelastic collision.

$$\sqrt{\frac{h_2}{h_1}} = \sqrt{\frac{h_1}{h_{initial}}}$$

10 Rotational Dynamic

Rotational dynamics is the branch of physics that deals with the motion of rotating objects and the forces and torques that cause this motion. It focuses on how rotational motion is influenced by external forces, similar to how linear motion is described by Newton's laws.

10.1 Converting Linear to Rotational

Linear s, Rotational θ
Linear v, Rotational ω
Linear a, Rotational α

10.2 Angular SUVAT Equations

$$\omega = \omega_0 + \alpha t$$
$$\omega^2 = \omega_0^2 + 2\alpha\theta$$
$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

The components and SI units are,

ω = angular velocity (rad/s)
θ = angle
α = angular acceleration (rad/s^2)

10.3 Torque 2 Electric Bungaloo

Torque is a measure of the rotational force applied to an object. It causes an object to rotate around an axis. In simple terms, it's the rotational equivalent of force in linear motion.

$$\tau = Fd$$

Where,

$$d = rsin\theta$$

Hence,

$$\tau = Frsin\theta$$

$$\Sigma\tau = \tau_1 + \tau_2 + \tau_3 + ...\tau_n$$

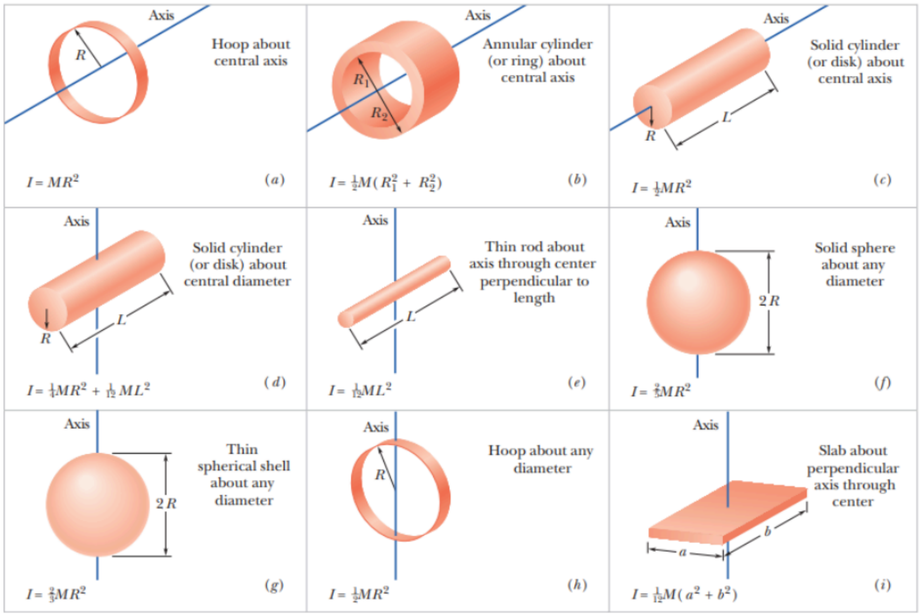
Components and SI Units are

τ = torque (Nm)
F = force (N)
r = radius (m)
d = distance (m)

Positive for Counter-Clockwise
Negative for Clockwise

10.4 Inertia

Inertia is the property of an object that resists changes to its motion. It is a fundamental concept in both linear and rotational dynamics. Inertia can be thought of as an object's resistance to both changes in velocity (linear inertia) and changes in rotational velocity (rotational inertia).



Note: you don't need to memorise this, this will be given.

Basic formula for inertia

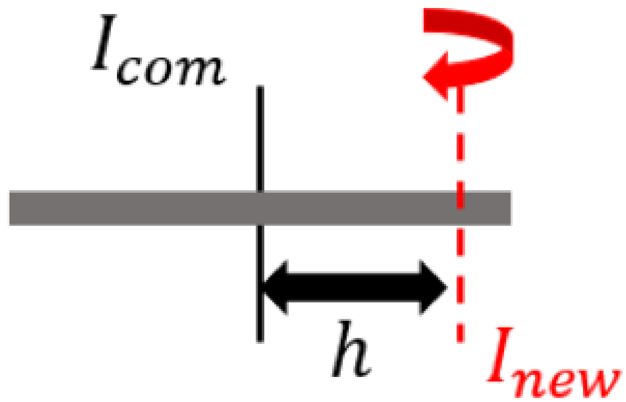
$$I = mr^2$$

$$\Sigma I = I_1 + I_2 + I_3 + ... + I_n$$

The components and SI Units are, I = inertia (kgm^2)

10.4.1 Parallel Axis Theorem

The Parallel Axis Theorem is a key concept in rotational dynamics that allows you to calculate the moment of inertia of an object about any axis, given the moment of inertia about a parallel axis that passes through the center of mass.



$$I = I_{com} + mh^2$$

The component and SI units are I = inertia (kgm^2) I_{com} = inertia in central of mass (kgm^2) m = mass (kg) h = distance from central rotational axis to newer rotational axis (m)

10.5 Relationship between Torque and Angular Acceleration

This relationship is governed by Newton's second law for rotation

$$\Sigma\tau = I\alpha$$

10.6 Angular Momentum

Angular momentum is a measure of the rotational motion of an object. It represents the amount of rotational motion an object has, and is dependent on both its momentum and the distance from the axis of rotation. It plays a similar role in rotational motion as linear momentum does in straight-line motion.

$$L = I\omega$$

The components and SI units are,

L = angular momentum (Nm)
I = inertia (kgm^2)
ω = angular velocity (rad/s)

10.6.1 Conservation Law of Angular Momentum

Angular momentum is conserved when no external torque acts on a system. This is known as the conservation of angular momentum, and it is similar to the conservation of linear momentum in linear motion.

$$\tau = \frac{\Delta L}{\Delta t} = 0$$

Where L is constant.

$$L_{initial} = L_{final}$$

$$I_i\omega_i = I_f\omega_f$$

10.7 Kinetic Energy in Angular Motion

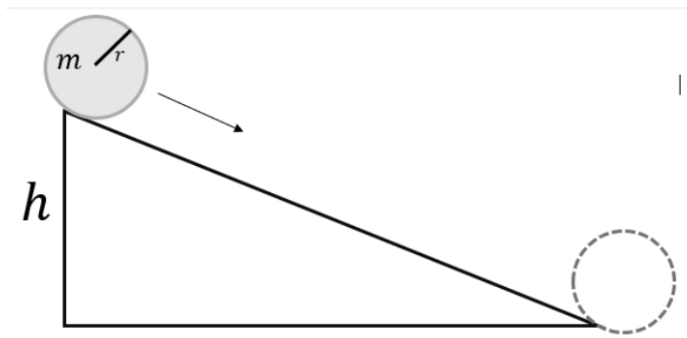
Kinetic energy in angular motion is the rotational equivalent of linear kinetic energy.

$$K_{rot} = \frac{1}{2}I\omega^2$$

Total Kinetic Energy of Translation and Rotation Motion

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Mechanical Energy using both Translation and Rotational Kinetic Energy



$$ME_1 = ME_2$$

$$KE_1 + PE_1 = KE_2 + PE_2$$

$$KE_{trans_1} + KE_{rot_1} + PE_1 = PE_2 + KE_{rot_2} + KE_{trans_2}$$

Because for some reason mr added another formula during physics support, might as well start writing.

$$v = \sqrt{\frac{2gh}{1+k}}$$

Where the k is a coefficient of I, for example

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

Where the k is $\frac{1}{2}$

And that's it, all of physics semester 1 recapped into 35 pages of pure madness, if you have further questions feel free to contact me (089516294589) or my email darrenkhosma@gmail.com. I used LaTeXusing the Overleaf compiler to make this, thank you for reading. Goodbye.