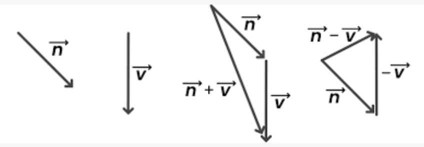
Newton's Laws of Motion

First Law:	Objects have inertia, i.e. a stationary object remains stationary, or a moving object keeps on moving at the same speed in the same direction, if there is no net force acting on it
Second Law:	Acceleration of an object is directly proportional to and in the same direction as the net force on it, and inversely proportional to its mass. $F_{net} = ma$
Third Law:	When object A exerts a force on object B, B exerts a force of the same magnitude in the opposite direction on A . $F_{on\ A\ by\ B} = -F_{on\ B\ by\ A}$

Vector Addition



SLM Constant Acceleration Equations

Uses:	**Equation**
v u a t	v = u + at
v u t s	s = 1/2 (u + v) t
u a t s	$s = ut + 1/2 at^2$
v a t s	$s = vt - 1/2 at^2$
v u a s	$v^2 = u^2 + 2as$

Interpreting Motion Grpahs

	d - t	**v - t**	**a - t**
Direct Reading	*d* at any *t* *t* at any *d*	*v* at any *t* *t* at any *v*	*a* at any *t* *t* at any *a*
Gradient	intsantaneous velocity at any point v_{avg} between any two points	instantaneous acceleration a_{avg}	-
Area under graph	-	change in position	change in velocity

Einstein's Special Relativity

Postulate One The Principle of Relativity	**Postulate Two** The Constancy of the Speed of Light
the laws of physics are the same in all inertial frames of reference (not just mechanics)	the speed of light is constant for all observers
there is no 'preferred' or 'correct' frames of reference	this implies a universal speed limit
	this has implications of simultaneity of events

Time Dilation

$t = t_0 \gamma$

$\gamma = 1 / \sqrt{*}1 - v^2/c^2$

t_0 is proper time, t is dilated time (larger than proper time), γ is the Lorentz Factor

Length Contraction

$L = L_0/\gamma = L_0 \sqrt{1 - v^2/c^2}$

L_0 is proper length, L is contracted length (small than proper length), and γ is still Lorentz factor

Relativistic Energy

- Einstein concluded that it takes energy to make mass, and energy is released if mass disappears. Energy released from nuclear fusion and fission is based on a difference in mass.

$m = relativistic\ mass$ and $m_o = rest\ mass$ $m = m_o\gamma$

$E_{tot} = mc^2$ and $E_{rest} = m_o c^2$

- $E_{tot} = E_k + E_{rest}$
- $E_k = E_{tot} - E_{rest}$
- $E_k = mc^2 - m_o c^2 = m_o\gamma\, c^2 - m_o c^2 = (\gamma - 1)m_o c^2$

Note 1: As an object approaches c, the mass becomes infinitely large. This would require an infinite force to increase the velocity of an object past the speed of light (ie. it's not possible)

Note 2: In the VCAA formula sheet, 'm' represents the rest mass

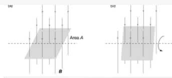
Magnetic Flux and Induced EMF

$$\Phi_B = \boldsymbol{B}_\perp A = \boldsymbol{B} A cos\theta$$

- Induced emf (Faraday's Law of Induction)

$\varepsilon = \frac{-\Delta\Phi_B}{\Delta t}$ $\varepsilon = \frac{-N\Delta\Phi_B}{\Delta t}$ for more than one loop

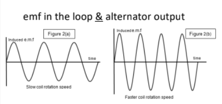
- Note that the flux needs to be changing over time (either the field strength or the area) to induce an emf
- The negative sign refers to the direction of the induced emf

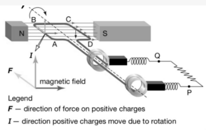


Magnetic flux is the amount of magnetic field passing through an area. In (a) it is the maximum BA; in (b) the value is less, as fewer field lines pass through the coil.

AC Generators (Alternators)

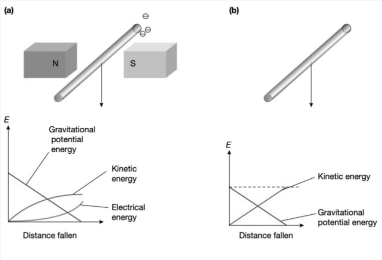
emf in the loop & alternator output



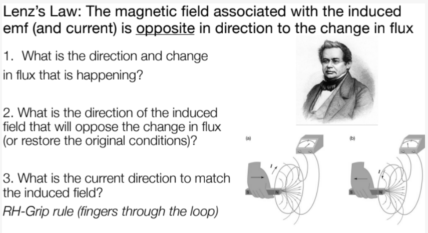


- AC Generators (Alternators) use slip rings
- Carbon brushes contact the slip rings
- Using the RH slap rule to determine current direction
- Using the RH grip rule to determine current direction

Induced EMF and Energy



Lenz's Law

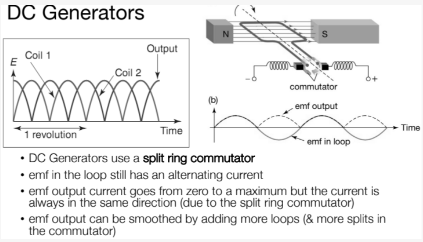


Transformer Equations

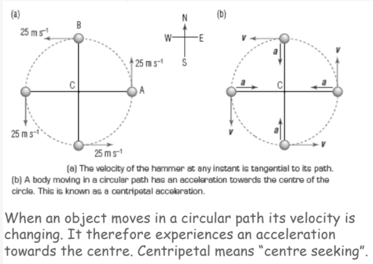
Across step-up and step-down transformers	$V_1 / V_2 = N_1 / N_2 = I_2 / I_2$

Where voltage and no. of turns are proportional to each other and current is inversely proportional.

DC Generators



Circular Motion



Centripetal Acceleration

1. Draw diagram showing all forces
2. If required, resolve forces into components
3. There is always a net force towards centre of circular path

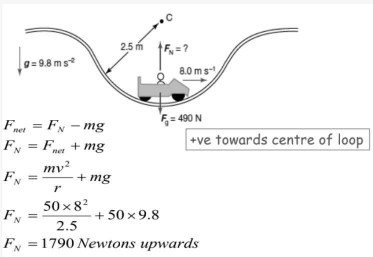
Useful equations:

$F_{net} = mv^2 / r$

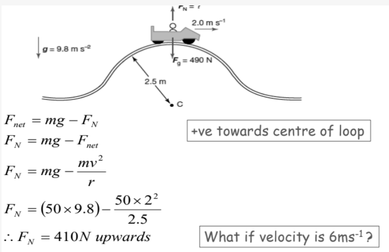
$v = 2\pi r / T$

$a = v^2 / r = 4\pi r^2 / T = 4\pi^2 f^2 r$

Motion at Bottom of Loop



Motion at Top of loop



Energy

Conservation of Energy in an isolated system, energy is transformed from one form to another, can neither be created nor destroyed	$E_k = 1/2mv^2$ $E_g = mg\Delta h$
Hooke's Law force exerted by spring is directly proportional, but opposite in direction, to the spring's extension or compression	$F_s = -kx$
Strain Potential Energy	$E_s = 1/2k\Delta x^2$

Gravity

Newton's Law of Universal Gravitation	Gravitation is a force of attraction that acts between any two bodies. The gravitational force between two bodies is given by: $F = GMm/r^2 = mg$

Gravity (cont)

Gravitational Fields	Vector field, a physical quantity with value at each point in space, existing in any region with gravitational effect *$g = f/M = GM/r^2$* (N kg^{-1}) = **a(m s^{-1})**
Free Falling Objects	influenced only by gravity net force given by: *$\Sigma F = mg$* *$a = \Sigma F/g = mg/g = g$*
Kepler's Law	*$R^3/T^2 = GM/4\pi^2$*

Gravity (cont)

Work done	objects moving through constant gravitational field *$E_g = mg\Delta h$* total energy of object moving through gravitational field is constant, even though relative amounts of kinetic and gravitational potential energy may change area under gravitational field-distance graph gives energy change per kilo of mass

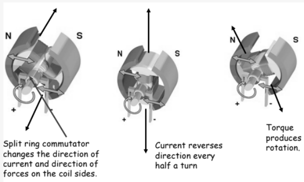
Electricity

Electric Fields	vector fields occurring around charged objects fields exert a non-contact force, may be attractive or repulsive
Force on Charged Particle	*$F = qE$*

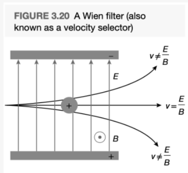
Electricity (cont)

Coulomb's Law	The electric force between two charges (q1, q2) is proportional to the product of the charges and inversely proportional to the square of the distance between them.
Point Charges	*$F = kq_1 q_2 / r^2$* where a positive value of force represents repulsion *$E = kQ / r^2$ (N C^{-1})*

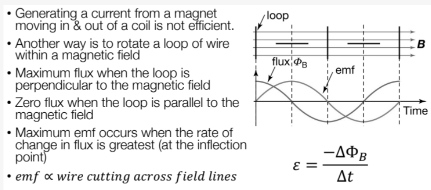
DC Motors (Split Ring Commutators)



Wein Filter

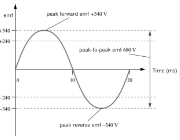


Changing the flux by rotating a loop



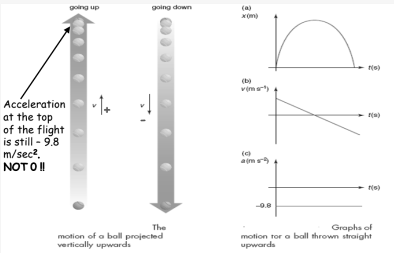
Root Mean Square Voltage

The steady (DC) voltage that produces the same power in a resister as an alternating voltage (AC)



- RMS Voltage, $V_{RMS} = \frac{V_{peak}}{\sqrt{2}}$
- RMS Current, $I_{RMS} = \frac{I_{peak}}{\sqrt{2}}$
- RMS Power, $P_{RMS} = V_{RMS} \times I_{RMS} = \frac{1}{2} V_p I_p$
- Peak Power, $P_p = V_p \times I_p = 2V_{rms} I_{rms}$
- Note: Unless specified, assume RMS values for V, I, P

Projectile Motion



Note that the ball will return to the ground with the **same speed** it was projected.

Momentum

"mass in motion"	$p = mv$
is a vector	$F_{net} = \Delta p / \Delta t$

A net force on an object will cause a change in momentum (Impulse)

Conservation of Momentum

If two objects collide in an isolated system, momentum will be conserved

initial momentum = final momentum

$\Sigma p_{initial} = \Sigma p_{final}$

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

OR $\Sigma p_{final} - \Sigma p_{initial} = \Delta p = 0$

Impulse

Impulse = $F_{net} \Delta t = m \Delta v = \Delta p$

is a vector

units are either N s^{-1} OR kg m s^{-1}

using this equation between two states gives us the average F_{net}

is area under force-time graph

Collisions

An isolated event (no external forces and momentum is conserved) involving 2 or more objects	**Elastic Collision** momentum and energy is conserved
Usually interact (often strongly) for a short period of time	**Inelastic Collision** momentum is conserved but energy is not (lost to usually heat and sound)

Equal and opposite impulses are exerted on each other

Work

Work(scalar) is the energy transferred to an object or transformed by the application of a force

Work is done by a force on an object when it causes a displacement of an object in the direction of the force

$W = Fs$

$W = Fs\cos\theta$*

Work done on an object:

$W = F_{net} s$

If the energy doesn't change, or force is perpendicular to displacement, no work is done on object

Work (cont)

is area under force-displacement graph

Magnets

Magnetic FIelds	vector fields, denser the lines means stronger the fields field lines go from north to south pole and never touch magnets are always dipole, can never be monopole
Earth as a Magnet	The Earth is one large magnet – believed to be due to convection currents of molten metals in the outer core True geographic north pole is actually magnetic south pole

Induced EMF in a Moving Conductor

- Recall a charge moving in a magnetic field:

$$F = qvB, \quad and\ also\ W = Fd$$

- If l is the length of the conductor over which the electrons travel, combining equations and equating to work per unit charge:

$$\varepsilon = \frac{Bqvl}{q} = lvB \text{ (J/C or Volts)}$$

Linear Particle Accelerators

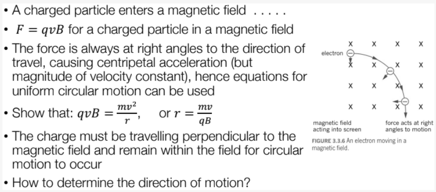
- We only consider the acceleration of particles in **uniform** electric and magnetic fields
- Electron gun: electrons are 'fired' from a hot **cathode** (negative charge) to an **anode** (positive charge)
- Electrons continue through a hole in the anode
- In a uniform electric field, recall:

$$F = qE \quad E = \frac{V}{d} \quad W = qEd \quad W = qV$$

- Work is also the change in kinetic energy of the particle

> $\frac{1}{2}mv^2 = qV$
>
> This is often referred to as the electron-gun equation.

Charged Particles in a Magnetic Field



Generating Voltage

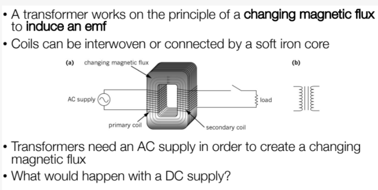
We know electric currents can produce magnetic fields

The separation of charges in the falling rod is an induced electromotive force or induced voltage (or potential difference)

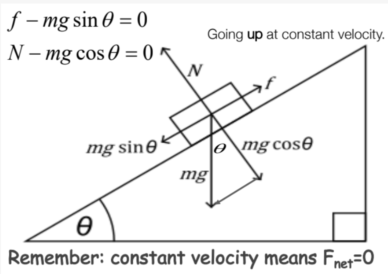
The object needs to keep moving, or the magnetic field needs to be changing for charges to remain separated (to maintain an induced voltage)

Electromotive force (emf), is a source voltage

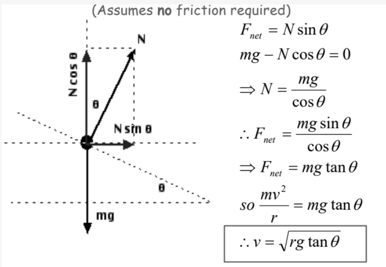
Transformers



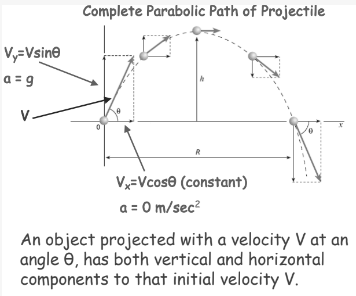
Inclined Plane



Banked Turn Design Speed



Projectile Motion



Projectile Range Formula

$R = u^2 \sin(20) / g$

assuming symmetric motion