Form 4 : Definition and Formulae

Chapter 1

- Physical quantities are quantities that can be measured
- Base quantities are physical quantities that cannot be defined in terms of other quantities. [Length(m), mass(kg), time(s), temperature(K), electric current(I), light intensity(cd) and quantity of matter(mol)]
- Derived quantities are physical quantities derived from combination of base quantities through multiplication or division or both multiplication and division
- Scalar quantities are physical quantities that have magnitude only
- Vector quantities are physical quantities that have magnitude and direction

Chapter 2

- Distance is defined as the total length of the path traveled from one location to another (m)
- Displacement is the distance traveled from its initial position to its final position (m)
- Speed is defined as the rate of change of distance (ms^{-1})
- Velocity is defined as the rate of change of displacement (ms^{-1})
- Acceleration is defined as the rate of change of velocity with time

$a = \frac{v-u}{t}$ $v^2 = u^2 + 2as$ $s = \left(\frac{u+v}{2}\right)t$ $s = ut + \frac{1}{2}at^2$

- Inertia of an object is the tendency of the object to remain at rest or, if it is moving, to continue its motion in a straight line. It depends on mass only
- Momentum of an object is defined as the product of its mass and its velocity

  p = mv ($kgms^{-1}$)

- Principle of conservation of momentum, when two or more bodies act on each other, their total momentum remains constant, provided that there is no external force acting on them

Elastic collision $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

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

Explosion $m_1v_1 = m_2v_2$

- Newton's First Law of Motion states that if the net force acting on a body is zero, it will stay at rest if the body is at rest or it will keep on moving at a constant speed in a straight line if the body is moving
- Newton's Second Law of Motion states that when a net external force acts on an object, the acceleration of the object is directly proportional to the net force and has a magnitude that is inversely proportional to its mass

  F = ma

- Newton's Third Law of Motion states that every acting force has an opposite and equal magnitude reacting force
- Impulse is defined as change of momentum
- Impulsive force is defined as the rate of change of momentum

$F = \frac{mv - mu}{t}$

- The gravitational field is a region in which an object experiences a force due to the gravitational attraction towards the centre of the Earth
- The gravitational acceleration is the acceleration of an object due to the pull of the gravitational force
- Weight is the gravitational force acting on an object with mass
- Frictional force is the force against the motion on an object
- Free falling objects will have a gravitational acceleration, g which is equal to 9.8 ms^{-1} (10ms^{-1})

Chapter 3

- According to the Newton's law of universe gravitation said that every object in the universe attracts other object with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between their centre

$F = G\frac{m_1 \times m_2}{r^2}$ G = Universal Gravitational constant

= 6.67 x 10^{-11} Nm^2kg^{-2}

- On the surface of the Earth, the gravitational field strength is given

$g = \frac{GM}{R^2}$

- At the distance r below the surface of the Earth (r<R), the gravitational field strength is given

$g` = \left(\frac{r}{R}\right)g$ $g` \propto r$

- At the distance h above the surface of the Earth (r = h +R), the gravitational field strength is given

$g`` = \left(\frac{R^2}{r^2}\right)g$ $g`` \propto \frac{1}{r^2}$

- Object will experience an acceleration towards the centre of the Earth due to the change in velocity and it is called centripetal acceleration

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

- The centripetal acceleration is always toward the centre of the Earth, there is a force acting on the object towards the centre of the Earth and it is called centripetal force

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

- Mass of the Earth and Sun can be calculated as following

$M_{Earth} = \frac{4\pi^2 R_{Earth}^3}{T^2 G}$ T = 24 hr $M_{Sun} = \frac{4\pi^2 R^3}{T^2 G}$ T = 365 days

R = distance between Earth & Sun

- Kepler's First Law states that the orbits of the planets are ellipses with the Sun in one of its focus
- Kepler's Second Law states that a line joining the planet with the Sun sweeps over equal areas in equal intervals of time as the planet moves in orbit
- Kepler's Third Law states that the square of the period is directly proportional to the cube of the orbital's radius
- A man-made satellite has to move with a orbital velocity, v, in order to maintain at a constant height

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

- The escape velocity is the minimum velocity an object must have in order to overcome the gravitational pull of the Earth and escape into outer space without falling back

$V_E = \sqrt{2gR}$

Chapter 4

- Thermal equilibrium is achieved when there is no net flow of heat between two objects and same temperature
- Temperature is the measure of the degree of hotness of an object

$^oC \xrightarrow{+273} K \xrightarrow{-273} {}^oC$

- Heat capacity of a substance is the amount of heat that must be supplied to increase the temperature by 1°C of the substance
- Specific heat capacity of a substance is the amount of heat that must be supplied to increase the temperature by 1°C for a mass of 1 kg of the substance

Q = mcθ

- Specific latent heat of fusion of a substance is defined as the amount of heat required to change 1 kg of the substance from the solid to the liquid phase without a change in temperature
- Specific latent heat vaporization of a substance is defined as the amount of heat required to change 1 kg of the substance from liquid to the gaseous phase without a change in temperature

Q = ml

- Boyle's law states that for a fixed mass of gas, the pressure of the gas is inversely proportional to its volume when the temperature is kept constant

$P_1V_1 = P_2V_2$

- Pressure law states that for a fixed mass of gas, the pressure of the gas is directly proportional to its absolute temperature when its volume is kept constant

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

- Charles' law states that for a fixed mass of gas, the volume of the gas is directly proportional to its absolute temperature when its pressure is kept constant

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Form 5 : Definition and Formulae

Chapter 5

- Wave is a traveling disturbance from a vibrating or oscillating source and its carry energy along with it in the direction of its propagation
- Transverse wave is a wave in which the particles of the medium oscillate in a direction perpendicular to the direction in which the wave moves
- Longitudinal wave is a wave in which the particles of the medium oscillate in a direction parallel to the direction in which the wave moves
- Amplitude, a of an oscillation is the maximum displacement from the mean position
- Period, T of the oscillation is the time taken to complete one oscillation
- Frequency, f of the oscillation is the number of complete oscillation made in one second $T = \frac{1}{f}$ $v = f\lambda$
- Damped oscillation, the amplitude of oscillation is decreasing with time. Damping causes part of the energy of the oscillating system to be lost as heat
- Resonance is occur when the forced frequency is equal to the natural frequency of the system, the amplitude is a maximum
- Reflection of waves occurs when all or part of the waves return after they encounter an obstacle or reflector
- Refraction of waves occurs when there is a change of direction of the propagation of waves traveling from a medium to another medium due to a change of speed
- Diffraction is the spreading of a wave as it goes through a narrow slit or passes round a small obstacle
- Interference is the effect of superposition of two waves from two coherent sources
- Coherent sources of waves produces waves of the same frequency, same amplitude and constant phase difference
- Principle of superposition states that at any time, the combined wave forms of two or more interfering waves is given by the sum of the displacement of the individual wave at each point of the medium
- Constructive interference is the superposition of two waves which are in phase to produce a resultant wave of maximum amplitude (antinode)
- Destructive interference is the superposition of two waves which are in phase to produce a resultant wave of minimum amplitude (node)

$$\lambda = \frac{ax}{D}$$

- The loudness of a sound is dependent on its amplitude
- The pitch of a sound heard depends on the frequency of the sound
- Speed of light or electromagnetic waves are constant 3 x 10^8 ms^{-1}

Gamma rays	X-Rays	UV rays	Visible light	Infrared	Microwaves	Radio waves

- From left to right of the table, frequency decreases but wavelength increases

Chapter 6

- Laws of reflection states that the incident ray, reflected ray and the normal all lie in the same plane, the angle of incidence is equal to the angle of reflection
- Refraction of light is the bending of a light ray at the boundary as it travels from one medium to another
- Light ray bends towards the normal when is travels from air to glass from a less dense medium to a denser medium
- Light ray bends away from the normal when it leaves the glass to air from a denser medium to a less dense medium
- Snell's law states that the ratio of sin i to sin r is equal a constant and the constant is known as refractive index speed of light in air or vacuum

$$n = \frac{\sin i}{\sin r} = \frac{\text{speed of light in air or vacuum}}{\text{speed of light in the medium}} = \frac{\text{real depth}}{\text{apparent depth}} = \frac{1}{\sin C}$$

- Critical angle, c is defined as the angle of incidence in the denser medium when the angle of refraction, r in the less dense medium is 90°
- If the angle of incidence, i is increased further so that it is greater than the critical angle, c (i>c), the light is no longer refracted but is internally reflected. This condition is called total internal reflection
- Real image is the image can be seen on the screen, but cannot be seen with eye without the screen, real image always inverted (+v)
- Virtual image is the image can be seen with eye, but cannot be captured on a screen, virtual image always upright (-v)

$P = \frac{1}{f}$ units for p is D (Diopter), + for convex lens, - for concave lens

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

$m = \frac{v}{u} = \frac{H_I}{H_O}$ m>1, magnified ; m<1 diminished ; m = 1 same size

Chapter 1

- Resultant force is the vector sum of all forces applied to an object
- A single force can be resolved into two perpendicular components
  $F_x = F \cos \theta$ $F_y = F \sin \theta$
- Resultant force for two perpendicular foces is

$$F = \sqrt{F_x^2 + F_y^2}$$

- Newton's First Law of Motion states that if the net force acting on a body is zero, it will stay at rest if the body is at rest or it will keep on moving at a constant speed in a straight line if the body is moving
- Newton's Second Law of Motion states that when a net external force acts on an object, the acceleration of the object is directly proportional to the net force and has a magnitude that is inversely proportional to its mass
  F = ma
- Newton's Third Law of Motion states that every acting force has an opposite and equal magnitude reacting force
- The forces are in equilibrium if the resultant force produced in all direction is zero
- Elasticity is a property of matter that enables an object to return to its original size and shape when the forces that are acting on it are removed
- Hooke's law states that the extension of a spring is directly proportional to the applied force provided the elastic limit is not exceeded
  F = kx
- Elastic potential energy is defined as work done is stored in the material for an elastic material
  $E_p = \frac{1}{2} kx^2 = \frac{1}{2} Fx$

Chapter 2

- Pressure is defined as the magnitude of the force acting perpendicularly to a surface per unit area of the surface

$P = \frac{F}{A}$ (Pa)

$P_{liquid} = h\rho g$

- The atmospheric pressure is the pressure exerted by the atmosphere on the surface of the Earth as well as all objects on the Earth
  P_{atm} = 1 x 10^5 Pa = 1 atm = 1 bar = 76 cmHg = 10 m of Water
- Gas pressure is depends on the number of particles, altitude, collision rate, temperature and volume
- Pascal's principle states that pressure applied to an enclosed fluid is transmitted uniformly to every part of the liquid and to the walls of the container of the liquid

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

- Archimedes' principle states that for a body wholly or partially immersed in a fluid, the upward buoyant force acting on the body is equal to the weight of the fluid it displaces
- Bernoulli's principle states that where the speed of a fluid is inversely proportional to the pressure

Chapter 3

- Electric current is defined as the rate of flow of charges
  Q = It (Coulomb)
- An electric field, E is a region surrounding a charged body, q where electrostatics force, F can be experienced

$$E = \frac{F}{q}$$

- Potential difference, V between two points is defined as the work done when 1 C of charge moves between the two points in an electric field

$$V = \frac{E}{Q}$$

- Ohm's law states that the current, I, flowing though a metal conductor is directly proportional the potential difference, V, across the conductor, if the temperature and other physical condition remain constant
  V = IR
- Resistance of a conductor is depends on length, crossed-sectional area, temperature and material type
- Series circuit

$R_T = R_1 + R_2 + R_3$ $V_T = V_1 + V_2 + V_3$ $I_T = I_1 = I_2 = I_3$ $V_1 = \left(\frac{R_1}{R_T}\right) V_T$

- Parallel circuit

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ $V_T = V_1 = V_2 = V_3$ $I_T = I_1 + I_2 + I_3$ $I_1 = \left(\frac{R_T}{R_1}\right) I_T$

- The electromotive force (e.m.f),E, of a dry cell is the total electric energy given to one coulomb of charge flowing through the cell
  E = IR + Ir
- Electrical energy and power

$E = VIt = I^2Rt = \frac{V^2}{R}t$ $P = \frac{E}{t}$

Chapter 4

- A solenoid is a long coil made up of several turns of wire like a cylinder
- An electromagnet is a coil which can produce a magnetic field, when a current is switched off, the coil loses its magnetism completely
- In DC motor, commutator changes the direction of the current through the coil every half cycle so that the coil continues to turn in one direction
- Electromagnetic induction is the production of an electromotive force (e.m.f) in a conductor when there is a relative motion of the conductor across a magnetic field
- Faraday's law states that the magnitude of the e.m.f induced in a conductor is directly proportional to the rate at which the conductor cuts the magnetic field lines
- Lenz's law states that the induced current always flows in a direction so that it opposes the change which is causing it
- Right hand grip rule is used to find the direction of the magnet for an electromagnet
- Fleming's left hand rule is used to find the direction of the force produces by a conductor carries current in the magnetic field
- Fleming's right hand rule is used to find the direction of the current flow produces but a motion in the magnetic field
- Direct current (DC) is a current that flows in only one direction
- Alternating current (AC) is a current that reverses its direction at fixed time intervals
- Transformer is an electrical device which increases or decreases an alternating voltage based on the principle of electromagnetic induction

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} \qquad Efficiency = \frac{V_s I_s}{V_p I_p} \times 100\%$$

Chapter 5

- Thermionic emission is the release of electrons from a heated metal cathode

  Maximum velocity, $v = \sqrt{\frac{2eV}{m}}$

- Semiconductor are a group of materials that can conduct better than insulators but not as good as metal conductor
- Doping is a process of adding a small amount of other substances to pure semiconductor to increase their conducting abilities
- Pure semiconductor doped with pentavalent atoms, increases the number of free electrons. The majority charge-carriers are the electrons, minority charge-carriers are the holes, is thus known as an n-type semiconductor
- Pure semiconductor doped with trivalent atoms, increases the number of free holes. The majority charge-carriers are the holes, minority charge-carriers are the electrons, is thus known as an p-type semiconductor
- A diode is a device that allows current to flow through it in one direction only
- A semiconductor diode can be made by joining a p-type and a n-type semiconductor, also called a p-n junction
- Rectification is the changing of AC into DC by using a diode
- A transistor is a silicon chip which consist of two p-n junctions back to back
  i) the emitter (E) acts as a source of charge carriers, providing electrons to the collector (C)
  ii) the base (B) controls the movement of charge carriers (electrons) from the emitter (E) to the collector (C)
  iii) the collector (C) receives the charge carriers from the emitter (E)

$$I_E = I_B + I_C$$
$$I_E > I_C > I_B$$

- Potential divider, at transistor circuit, voltage at resistor R_B for base, $V_B < V_C$ voltage at resistor R_C for collector

$$V_B = \left(\frac{R_B}{R_B + R_C}\right) \times V_{Battery} \qquad V_C = \left(\frac{R_C}{R_B + R_C}\right) \times V_{Battery}$$

Chapter 6

- Isotopes are atoms of the same element with the same number of protons but different number of neutrons
- The unstable isotopes are called radioactive isotopes or radioisotopes
- Radioactivity is the spontaneous and random emission of radioactive rays from unstable radioactive materials after which they become more stable
- Half-life of a radioactive element is the time taken for half the number of atoms in a sample of radioactive atoms to decay
- Nuclear energy is released during decay or reaction of the radioactive nucleus, this is because some of the mass in the reactant is converted into energy

$$E = mc^2$$

- Nuclear fission is the splitting of a nucleus with big mass into two or more smaller nuclides with release energy
- Nuclear fusion is the combination of small atoms into a larger atom and with the release of heat energy

Characteristic	α	β	γ
Nature	Helium atom, 2 protons, 2 neutrons, positively charged	Electron, negatively charged	Electromagnetic wave, neutral
Electric field	Deflected to negative plate	Deflected to positive plate	No deflection
Magnetic field	Deflected perpendicular with the magnetic field	Deflected perpendicular with the magnetic field	No deflection
Ionising /penetrating power	High / low (Stopped by paper)	Moderate (Stopped by aluminium)	Low / high(Stopped by lead)
Speed	10% speed of light	99% speed of light	Speed of light (3×10^8 ms^{-1})

Chapter 7

- Light energy cannot be emitted continuously as wave, but in the form of small packet of energy
- Black body is an excellent absorber and emitter of electromagnetic radiation, including light and heat
- Black body radiation is the electromagnetic radiation emitted by a black body
- Quanta (discrete energy packets) is introduced by Planck to explain wave properties especially on the high frequency and low wavelength
- Albert Einstein is suggesting light exists in the form of quanta as photon
- Photon is a particle with zero mass consisting of quantum electromagnetic radiation in which its energy is concentrated
- Louis de Broglie is found that particles exhibit wave properties, hence the idea of wave-particles duality of light is applied
- Electromagnetic energy is quantized, $E = hf$
- For a subatomic particles, momentum is

$$P = \frac{h}{\lambda} \qquad p = mv$$

- Photoelectric effect is happened when a metal surface is illuminated with light, electrons are emitted and it's depends on light intensity, light frequency or wavelength
- A minimum energy required by an electron to exit from metal surface is called work function, W
- $W = hf - \frac{1}{2} mv^2$
- Threshold frequency, fo is minimum frequency of the incident light which can cause the release of photoelectric on the metal



Good luck !!!