PHYSICS UNIT 1

MODULE 1

Resolving Forces

When resolving forces to find resultant force:

1. Resole al forces horizontally and vertically
2. Find horizontal resultant force
3. Find vertical resultant force
4. Apply parallelogram law or Pythagoras Theorem

NB: Pay close attention to direction of forces.

Base Quantities and Base Units

There are seven base quantities and seven corresponding base units outlined by system International (S.I).

Base Quantity	**Base Unit**
Mass, m	Kilogram (kg)
Length, l	Metre (m)
Time, t	Second (s)
Temperature, T	Kelvin (K)
Electric current, I	Ampere (A)
Amount of substance, n	Mole (mol)
Luminous intensity, I_v	Candele (cd)

The Mole- is the amount of substance which contains as many elementary units (atoms/ ions/molecules) as there are atoms in 0.012kg of carbon – 12.

The number of elementary units per mole is called the ***Avogadro constant***, ***N_A***. it is the same for all the substances.

$N_A = 6.02 \times 10^{23}$ mol^{-1}

Derived Quantity and Derived Units

Derived Quantity	**Derived Unit**
Area A = L × B (rectangle)	m × m = m^2
Volume V = L×B×H (cuboid)	m × m × m = m^3
Density $\rho = \frac{m}{v}$	$\frac{kg}{m^s}$ = kg ms^{-3}
Speed v = $\frac{s}{t}$	$\frac{m}{s}$ = ms^{-1}
Acceleration a = $\frac{v-u}{t}$	$\frac{ms^{-1}}{s}$ = ms^{-2}
Force F = ma	Kg × ms^{-2} = $kgms^{-2}$ = Newton (N)
Pressure P = $\frac{F}{A}$	$\frac{N}{m^2}$ = Nm^{-2} or Pascal (Pa)
Work W = F × g	N × m = Nm or Joule (J)
Power P = $\frac{W}{T}$	$\frac{J}{s}$ = Js^{-1} or Watt (W)

Dimensional Analysis

Used to determine if there exist a relationship between quantities.it cannot be used by itself to determine the accuracy of a formula.

Errors

Random Error- When repeated measurements of the same quantity give rise to different **values**. A random error is said to have occurred.

Systematic Error- A systematic error changes all measurements of a particular quantity equally.

Precision and Accuracy- A accurate experiment is one in which the **systematic error is relatively small.**

A **precise experiment** is one in which the **random error is relatively small**.

NB: Regardless of the operation (-, +, ÷, ×) uncertainties are always added. So generally: If $y = \frac{Ab^n}{c}$ then $\frac{\Delta y}{y} = \frac{\Delta A}{A} + n\left(\frac{\Delta b}{b}\right) + \frac{\Delta c}{c}$

Resistive forces

Up thrust on a Body in Fluid

F = P× A → F = ρgh A

Terminal Velocity

- a = 0, $F_r = 0$

Equations of Motion

1. By definition: $a = \frac{u-v}{t}$

   at = v – u

   v = u + at…(1)

2. Average velocity = $\frac{s}{t}$

   Iff a = constant   Average velocity=$\frac{u+v}{2}$

   → $\frac{s}{t} = \frac{u+v}{2}$

   $S = (\frac{u+v}{2})$ t……..(2)

3. Sub $t = \frac{v-u}{a}$ from 1 in 2

   $S = (\frac{v+u}{2})(\frac{v-u}{a})$

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

   $2as = v^2 - u^2$

   $V^2 = u^2 + 2as$………..(3)

4. Sub v = u + at from 1 in 2

   $S = (\frac{u+(u+at)}{2})$ t

   $S = ut + \frac{1}{2}at^2$………(4)

5. Sub u = v – at from 1 in 2

   → $s = \left(\frac{v-at+v}{2}\right)$ t

   $S = vt - \frac{1}{2}at^2$…….(5)

Projectiles

The horizontal components of velocity remain constant throughout motion. However, the vertical component of velocity is affected by g and therefore changes with time. The equations of motions can therefore be used when considered the vertical motion of the projectile.

Newton's Laws of Motion

Newton's First Law

A body continues in its state of rest or of uniform motion in a straight line (i.e. uniform velocity unless acted upon by a resultant force).

The **inertia** of a body is the resistance to change in motion and therefore Newton's First Law is sometimes called the law of inertia.

Mass	Weight
Is the measure of the inertia of a body.	Is the force which gravity exerts on a body.
Unit: kg	Unit: N
Scalar	Vector
Constant	Varies according to the gravitational field strength.
Fundamental quantity	Derived quantity

Newton's Second Law

The rate of change of momentum of a body is directly proportional to the resultant force acting on the body and takes place in the direction of the force

Newton's Third Law

When object A exerts a force on B, object B exerts an equal and opposite force of an object A.

Linear Momentum: mv (vector quantity)

Perfectly Elastic Collision

- Energy (kinetic) conserved
- Momentum conserved
- Impulse= Ft = mv – mu

Area under force - time graph is impulse

Circular Motion

S = rϴ	W = $\frac{\theta}{t}$	W = $\frac{2\pi}{T}$
V = rw	a = w^2 r	a = $\frac{v^2}{r}$
f = $\frac{w}{2\pi}$	F = mw^2r	F = $\frac{mv^2}{r}$

Vertical Circle:

At A: T + mg = $\frac{mv^2}{r}$

At B: T = $\frac{mv^2}{r}$

At C: T – mg = $\frac{mv^2}{r}$

Horizontal Circle:

Tension = centripetal force

T = mw^2r

Questions:

1. **2023 #1(d), (e)**
2. **2021 # 1 (d)**

Gravitation

A gravitational field is said to exist at a point if a gravitational force is exerted on a mass placed at the point.

Notes:

- Gravitational forces are always forces of attraction
- Gravitational forces are mostly negliable unless atleast one very massive body is involved. Example: the earth
- The direction of the gravitational field at a point is the direction of the force exerted on a mass at that point.

Newton's Law of Gravitational Field Strength

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

$g = \frac{F}{M} = \frac{GM}{r^2}$

Planets orbiting sun: $mrw^2 = \frac{mv^2}{r} = \frac{Gm_1m_2}{r^2}$

Geostationary orbits: period = 24 hours

$T^2 \propto r^3$

Apparent weight = Gravitational force – centripetal force

Questions:

1. **2023 #1(f) , (g)**
2. **2021 #1 (e)**

Work, Energy and Power

Work, W

Work done by the force whose points of application moves through a displacement in the direction of the force is the product of the force and displacement.

$W = F_s$

Energy, E.

Definition: The energy is the capacity to do work

Notes:

- S.I units Joule (J), 1J = 1Nm

Types of Energy

Mechanical Energy – K.E

- P.E

Energy Conversions

Example: Oil power generator

Chemical → Thermal → Mechanical→ Electrical.

Hydroelectric generator

- car

- light bulbs

Principle of Conservation of Energy

The total energy in a closed system is to be conserved.

Kinetic Energy, E_k

Is the energy that the body possess by virtue of its motion.

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

$V = \sqrt{2gh}$

Potential Energy, E_P

Potential energy is the energy that the body possesses by virtue of its state or position.

$E_p = mgh = Ek$

Power, P

Definition: Power is defined as the work done or energy transferred per unit time.

$P = \frac{W}{t}$ or $P = \frac{E}{t}$

Questions

1. **2017 # 4**

MODULE 2

A system which is to be set in mechanical oscillation must have:

1. Store P.E
2. Have interior

F = $\frac{1}{T}$,W = $2\pi f = \frac{2\pi}{T}$

Simple Harmonic Motion

	Starting at max. Displacement	Starting at zero displacement
Displacement	x = $x_0 \cos\theta$	x = $x_0 \sin\theta$
	θ = wt => x^2 $x_0$cos wt	θ = wt x = x_0 sin wt
Velocity	V =$\frac{dx}{dt}$	V = $\frac{dx}{dt}$
	V = -wx_0 sin θ	V = wx_0 cosθ
	V = - wx_0 sin wt	V = wx_0 cos wt
Acceleration	a = $\frac{d^2x}{dx^2}$ or $\frac{dv}{dt}$	a = $\frac{d^2x}{dt^2}$ or $\frac{dv}{dt}$
	a = -w^2 x_0 cos wt	a = -w^2x_0 sin wt
	a = -w^2x	a = -w^2x

To determine if a body moves with SHM

- Draw a diagram with the body at an arbitrary displacement, x from the equilibrium position, O.
- On the diagram, mark in all the force acting on the body and determine the resultant force in the direction of the displacement, x.

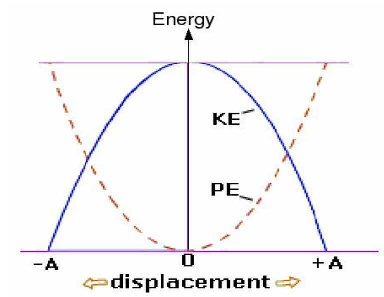
For helical spring: T = $2\pi\sqrt{\frac{m}{k}}$ = $2\pi\sqrt{\frac{e}{g}}$

For pendulum: T = $2\pi\sqrt{\frac{l}{g}}$

K.E and P.E

Ep = $\frac{1}{2}$mw^2 x^2

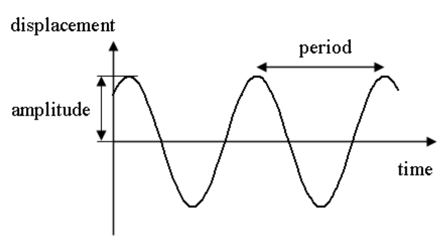
E_k= $\frac{1}{2}mw^2(x_0^2 - x^2)$



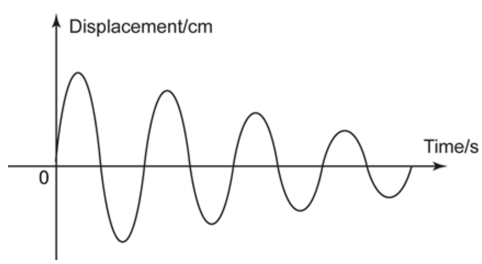
Damping

Is the process in which energy is taken from an oscillating system to do work in overcoming dissipated forces.

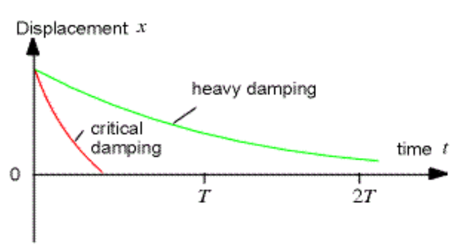
Undamped



Light

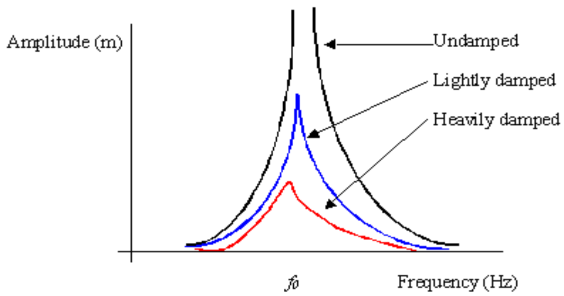


Critical

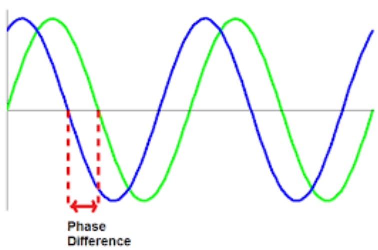


To keep a damped system in continuous oscillation a driving force must be applied.

Resonance → large oscillations when natural frequency = driving frequency



Phase Difference



Phase Difference Ø = $\frac{x}{\lambda} * 2\pi$

A leads B

B lags A

- v = fλ
- Intensity = $\frac{Power}{Area}$ Intensity ∝ Amplitude^2
- Polarization restricting oscillation

Stationary Waves

Are produced by the combination of 2 identical waves travelling in opposite directions.

Stationary waves are produced by the combined effect of two identical waves travelling in opposite directions i.e. it is the superposition of two waves with the same speed, frequency and amplitude travelling in opposite directions.

26.3.01 Standing waves in air columns

	Harmonic	Frequency	Standing wave	Wavelength
Air column closed at one end	1st harmonic (fundamental)	$f_0 = v/4L$ (natural)	L; n a	λ = 4L
	2nd harmonic	$3 f_0$	n a n a	λ = 4/3 L
	3rd harmonic	$5 f_0$	n a n a n a	λ = 4/5 L
Air column open at both ends	1st harmonic (fundamental)	$f_0 = v/2L$ (natural)	L; a n a	λ = 2 L
	2nd harmonic	$2f_0$	a n a n a	λ = L
	3rd harmonic	$3 f_0$	a n a n a n a	λ = 2/3 L

n = node, a = antinode

Refraction

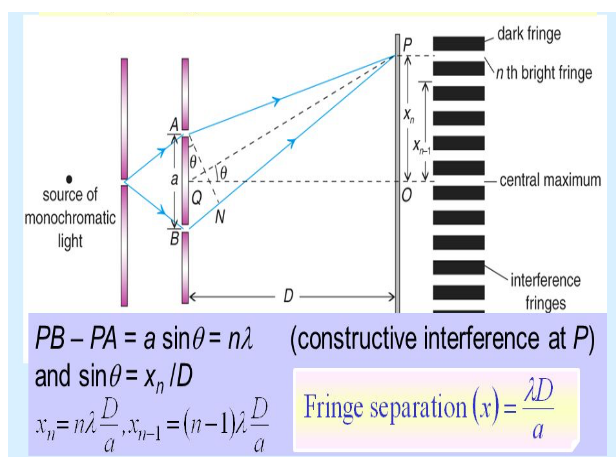
$n_2 = \frac{\sin\theta_1}{\sin\theta_2}$ = constant (Snell's Law) = $\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

$n_2 = \frac{1}{n_1}$

Total Internal Reflection: c = $\sin^{-1}(\frac{1}{n})$

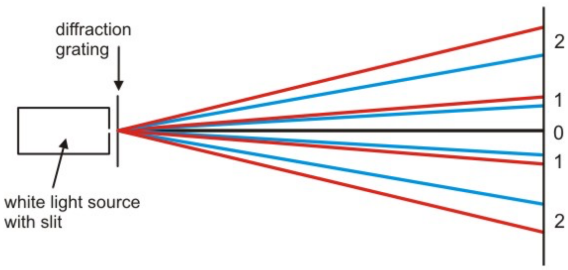
i > c ray in denser medium

Interference = y = $\frac{D\lambda}{a}$



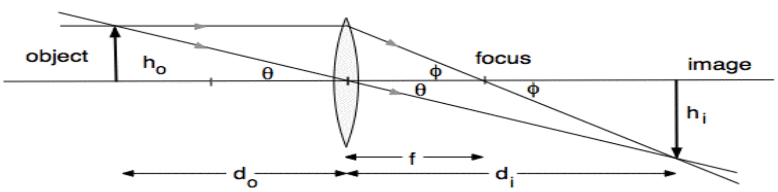
Diffraction Of Light: d sin Θ = n λ

for white light



n is max when Θ = 90^0

LENSES



m = $\frac{m}{u}$, Power = $\frac{1}{F}$

+ ve = converging

- ve = diverging

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

v + ve real

v – ve virtual

Intensity level = lg ($\frac{I}{I_0}$)

Or I (dB) = lg ($\frac{I}{I_0}$)

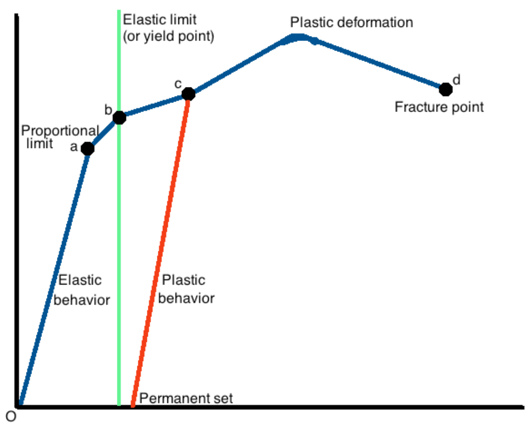
Module 3

Pressure = $\frac{force}{Area}$ (Pa)

Density = $\frac{Mass}{Volume}$

$Pressure_{Liquid}$ = ρgh

Hooke's Law



F = ke

A * Limit of proportionality

A → B :- Elastic Limit

B→ C :- Plastic Deformation

Stress = $\frac{Force}{Area}$ (Pa)

Strain = $\frac{Extension}{Original\ lenght}$

Youngs Modulus = $\frac{\textbf{Stress}}{\textbf{strain}} = \frac{\textbf{F l}}{\textbf{A e}}$

Strain Energy = $\frac{1}{2}$ Fx = $\frac{1}{2}kx^2$ = Area under F – e graph

Thermometric Property: Physical property that changes continuously with temperature and remains constant when temperature is constant.

Liquid in glass = Expansion on liquid

Resistance thermometer = resistance of platinum

Thermocouple = emf

Empirical Scale = $\Theta = \frac{x_\Theta - x_0}{x_{100} - x_0} \times 100$

Kelvin Scale = T = $\frac{P_t}{P_{tr}} \times 273.16$

$E_H = MC\Delta\Theta$

E_H = temperature change

E = mlf = phase change

C = mc = heat capacity

Internal Energy = Sum of $E_K + E_P$

Conduction = $\frac{Q}{t} = kA\ \frac{\Theta_2 - \Theta_1}{l}$ = - KA $\frac{\Delta\Theta}{\Delta x}$

Equivalent thickness: $\frac{k_1}{l_1} = \frac{k_2}{l_2}$

Poor Conductor: High $\frac{\Delta\Theta}{\Delta x}$

Good Conductor: Low $\frac{\Delta\Theta}{\Delta x}$

Radiation: P= A $(T_1^4 - T_2^4)$

Ideal Gas Equation: PV = nRT or PV = NKT

Also PV = $\frac{1}{3}$ Nm c^2 and $E_K = \frac{3}{2}$KT

Work Done: W = PΔV therefore Δv = 0→ W = 0

First Law of Thermodynamics: Δu = $\Delta\theta$ +Δw

Δu = $\Delta\theta$ - Δw

Adiabatic: $\Delta\theta$ = 0 therefore $\Delta u = \Delta w$

Isothermal: $\Delta u = 0$

Molar Heat Capacity

Constant Volume → Δu = n C_v ΔΘ

→ ΔQ = n C_v ΔΘ

→ ΔQ = n C_p ΔΘ

$C_p - C_v = R$