Physics Set A

Group. A

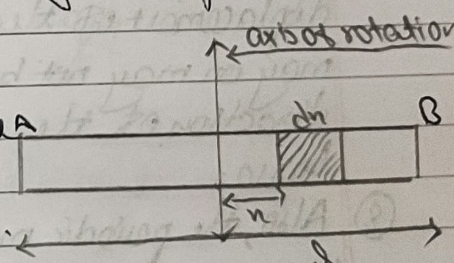
① ⓒ	④ a	⑦ c	⑩ a
② b	⑤ a	⑧ b	⑪ b
③ d	⑥ c	⑨ b	

Group - B.

1 ⓐ ⇒ Couple of forces is a set of two equal and opposite forces acting along different lines of actions in the same body
One example of it that is applied in our home is.
① Force applied while opening and closing the cap of the bottle

ⓑ

⇒ Sol"
Consider a thin uniform rod AB of length l, having mass M rotating about an axis passing through its centre and perpendicular to its plane.



Let dn be the small part in the rod at a distance 'n' from the axis of rotation. The moment of inertia of the small part is given by:-

$$dI = dm . n^2$$

where, dm is the mass of the small portion.

The dm is given by

$$dm = \frac{M}{l} . dn$$

$$\therefore dI = \frac{M}{l} n^2 dn$$

∴ Therefore, the M.I of the rod about axis XY.

$$I = \int_{-l/2}^{l/2} dI = \int_{-l/2}^{l/2} \frac{M}{l} n^2 dn$$

$$\frac{M}{l}\int_{-l/2}^{l/2} x^2\,dx$$

$$= \frac{M}{l}\left[\frac{x^3}{3}\right]_{-l/2}^{l/2}$$

$$= \frac{M}{l}\left(\frac{(l/2)^3}{3} - \frac{(-l/2)^3}{3}\right)$$

$$= \frac{M}{l}\left[\frac{l^3}{24} + \frac{l^3}{24}\right]$$

$$= \frac{M}{l}\left[\frac{l^3}{12}\right] = \frac{Ml^2}{12} \text{ Ans}$$

2(a)

Periodic Motion	Simple Harmonic Motion
① In the periodic motion, the displacement of the object may or may not be in the direction of the restoring force.	In the simple HM, the displacement of the object is always in the ~~direction~~ opposite direction of the restoring force
② Also, the periodic motion may or may not be oscillatory.	② And the SHM is always oscillatory
③ Example of Periodic motion. The motion of the hands of a clock, the motion of the wheels of a car etc.	③ Example of SHM are The motion of a pendulum, motion of a spring etc

2(b)

2(b)

⇒ Sol^n

give period on the earth of simple pendulum is $T_e = 1.60$ s

The gravitational acceleration on Mars is $g_m = 3.75\ m/s^2$

we know in pendulum,

$$T = 2\pi\sqrt{\frac{l}{g}} \quad -(1)$$

period of the pendulum on earth

$$T_e = 2\pi\sqrt{\frac{l}{g_e}} \quad -(2)$$

when g_e = gravity of earth

period of the pendulum on mars.

$$T_m = 2\pi\sqrt{\frac{l}{g_m}} \quad -(3)$$

from eq^n (2) and (3), we get

$$\frac{T_m}{T_e} = \sqrt{\frac{g_e}{g_m}}$$

$$T_m = T_e\sqrt{\frac{g_e}{g_m}}$$

$$= 1.6\sqrt{\frac{9.8}{3.71}}$$

$= 2.6$ seconds

12 or (a) ⇒ The phenomenon of rise or fall of a liquid in a capillary tube is called capillarity.

The cotton threads have large number of capillary in them. Due to capillary action, these capillarities help to absorb sweat from the surface of the body. As a result of it, the proper perspiration from the pores of skin will take place and one feels fresh. So, undergarments are made up of cotton.

or (b)

⇒ Soln

Given, internal diameter (d) = 3mm = 3×10^{-3} m

internal radius (r) = 1.5×10^{-3} m

Surface tension (T) = 0.545 Nm^{-1}

density of mercury (ρ) = 13.6×10^{3} kgm^{-3}

Angle of contact (θ) = 140°

we have

$$h = \frac{2T\cos\theta}{r\rho g} = \frac{2 \times 0.545 \times \cos 140°}{1.5 \times 10^{-3} \times 13.6 \times 10^{3} \times 9.8}$$

$$= -4.1766 \times 10^{-3}$$

(-) -ve sign indicates the depression of liquid

5(a) ⇒ When we blow air with our narrow mouth open, air is compressed at the lips and then rapidly expands and cools adiabatically by losing internal energy, resultanting in the air feeling cool at the hand. Hence, adiabatic expansion is involved in this process whereas,

When the mouth is made wide open, it is only slightly compressed at the lips and then expands only a little. Although this causes ~~some~~ some slight adiabatic cooling, the air still feels warm at the hand.

(b) ⇒ In case of petrol engine, adiabatic process occur in second stroke (compression stroke) and third stroke (working stroke). Adiabatic compression occurs in second stroke and adiabatic expansion takes place in third stroke.

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(b)

=>

(c) => Sol

given,

Energy supplied to the heat engine in 1 hr,

~~Equivalent~~ $H = 7.46 \times 10^5$ cal.

Equivalent work, $W = JH$

$= 4.2 \times 7.46 \times 10^5$ Joules

work output of the engine in 1 hr

$= 30\%$ of $4.2 \times 7.46 \times 10^5$ Joules

$= \frac{30}{100} \times 4.2 \times 7.46 \times 10^5$ J

$= 939.96 \times 10^3$ J

Power $= \frac{\text{work output}}{\text{time}}$

$= \frac{939.96 \times 10^3}{60 \times 60}$ watts

$= 261.6$ watts.

4 (a) =>

(b)

4 (a) ⇒ Huygen's principle states that every point on a wavefront is in itself the source of spherical wavelets. The sum of those spherical wavelets forms the wavefront.

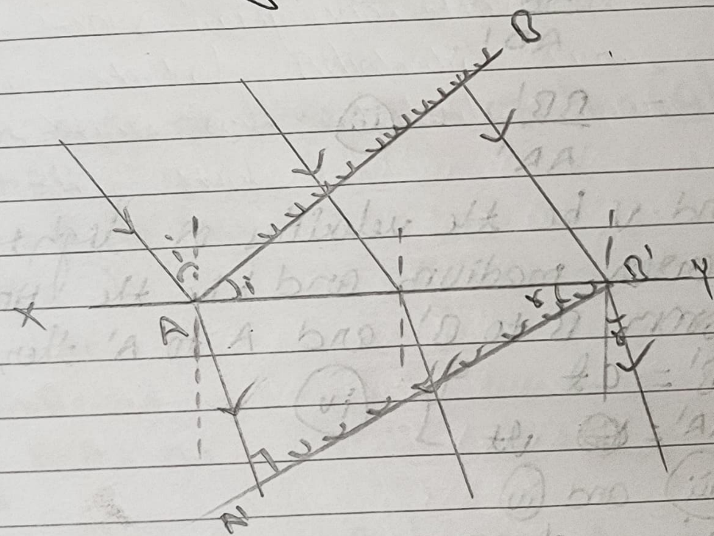
According to Huygen's Principle:-

i) Each point on the primary wavefront acts as a source of new disturbance called secondary wavelets.

ii) The secondary wavelets spread out in all direction with the speed of light as source does.

iii) The forward envelope of the secondary wavelets at any instant gives the shape of new wavefronts. i.e. the new wavefront is found by constructing a surface tangent to the secondary wavelets

(b).



Let us consider a plane wavefront AB is incident on refracting surface XY such that making angle of incidence 'i' as in the figure.
The point A of the surface XY becomes source of disturbance at first and point B becomes source of disturbance at last. When the disturbance from B reaches to B' during the same ~~period disturbance~~ ~~from B reaches to~~ interval of time the

disturbance from A reaches to A'
Therefore A'B' is a plane wavefront which is called refracted wavefront. Each and every point of the plane A'B' has a same phase

In $\Delta ABB'$ ~~and $\Delta AA'B'$~~

$$\sin i = \frac{BB'}{AB'} \quad \text{—(i)}$$

In $\Delta AA'B'$

$$\sin r = \frac{AA'}{AB'} \quad \text{—(ii)}$$

Dividing (i) by (ii)

$$\frac{\sin i}{\sin r} = \frac{\frac{BB'}{AB'}}{\frac{AA'}{AB'}}$$

$$\frac{\sin i}{\sin r} = \frac{BB'}{AA'} \quad \text{—(iii)}$$

If c and v be the velocities of light in rearer and denser medium and t be the time to reach from B to B' and A to A' then,

$$\left.\begin{aligned} BB' &= ct \\ \text{and } AA' &= vt \end{aligned}\right\} \text{(iv)}$$

from (iii) and (iv)

$$\frac{\sin i}{\sin r} = \frac{ct}{vt}$$

$$\frac{\sin i}{\sin r} = \frac{c}{v}$$

$$\frac{\sin i}{\sin r} = \mu$$

the incident plane wavefront (AB), refracted wavefront (A'B') and refracted surface (XY) all are perpendicular to the same plane so, incident ray, refracted ray and normal all lies in the same plane. proved

uor (a)
1.
2.
3
4
(b)

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uor (a)

Interference

1. It is due to the superposition of light coming from two different wavefronts originating from the same source
2. All bright and dark fringes are of equal width.
3. Points of minimum intensity are perfectly dark.
4. All bright bands are of uniform intensity

Diffraction.

1. It is due to the superposition of light coming from different parts, i.e wavelets of the same wavefront
2. Diffraction fringes are not of the same width
3. Points of minimum intensity are not perfectly dark.
4. All bright bands are not of same intensity

(b) ⇒ Soln

given, angle of diffraction of line $(\theta) = 30^\circ$

$n = 2$

$\lambda = 5 \times 10^{-5}$ cm

$N = ?$

we know

$d \sin\theta = n\lambda$

$\frac{1}{N} \sin\theta = n\lambda$

$N = \frac{\sin\theta}{n\lambda} = \frac{\sin 30^\circ}{2 \times 5 \times 10^{-5}} = 5000$ lines per cm.

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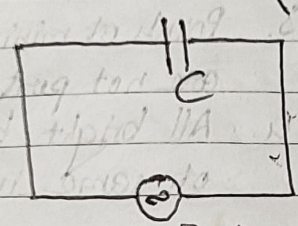
OR. S.

(a) => Let an alternating emf, $E = E_0 \sin\omega t$ is applied across a capacitor of capacitance C.

The current flowing in the circuit transfers charge to the plates of the capacitor due to which a potential difference develops across its plates. Also, assume that 'q' be the charge on each plate of the capacitor at any instant t.



$E = E_0 \sin\omega t$

The potential difference across the plates of capacitor, $V = \frac{q}{C}$

At every instant potential difference V must be equal to the applied emf

i.e, $V = \frac{q}{C} = E = E_0 \sin\omega t$ — (i)

$[\because E = E_0 \sin\omega t]$

$q = CE_0 \sin\omega t$

Instantaneous current,

$$I = \frac{dq}{dt} = \frac{d(CE_0 \sin\omega t)}{dt}$$

$$= CE_0 \cos\omega t . \omega$$

$$I = \frac{E_0}{\frac{1}{\omega C}} \sin\left(\omega t + \frac{\pi}{2}\right) \quad \text{— (ii)} \quad \left[\because \sin\left(\theta + \frac{\pi}{2}\right) = \cos\theta\right]$$

The current is maximum i.e. $I = I_0$ when $\sin\left(\omega t + \frac{\pi}{2}\right) = 1$

from eq^n (i)

On (b)

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$$I_0 = \frac{E_0}{\frac{1}{\omega C}} \times 1 = \frac{E_0}{\frac{1}{\omega C}} \quad \text{— (iii)}$$

Putting in eqn (ii) we get,

$$I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

Comparing eqn (i) and (iii) we see that in an A.C circuit containing capacitor only, current leads the emf by a phase angle of $\frac{\pi}{2}$.

Or (b)

=> Soln

given, $V_{rms} = 220\ V$

$f = 50\ Hz$

then,

$V = V_0 \sin\omega t$ — (i)

and $V_0 = \sqrt{2}\ V_{rms}$

$= \sqrt{2} \times 220$

$= 311$ volts

$\omega = 2\pi f = 2\pi \times 50 = 100\pi$

from (i)

$V = 311 \sin 100\pi t$

6 (a) → Lenz's law states that, "the direction of induced emf in any closed loop is such that it tends to produce a current that creates a magnetic flux to oppose the cause, i.e change in magnetic flux that produces it."

Consider a closed coil placed near a bar magnet north pole pointing towards it

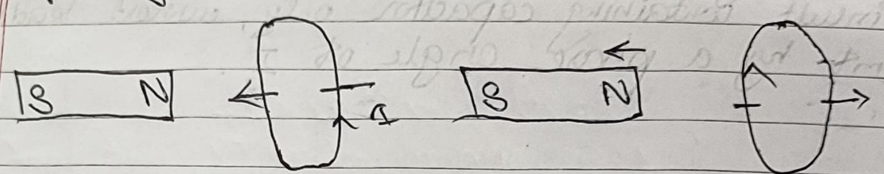

Fig Demonstration of Lenz law

If north pole of the magnet is moved towards the coil, the magnetic lines of force passing through the coil changes and hence current is induced in the coil. The direction of induced current is such that it oppose to the motion of magnet towards the coil. (cause). This is possible only current is in anticlockwise direction so that magnetic field due to induced current oppose the approaching magnet. Similarly, when the magnet is taken away, the induced current will be clockwise direction so that field due to induced current attract the magnet (fig). Thus in both cases direction of induced current is such that it opposes

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7 ⓐ ⇒ No, X-ray diffraction experiment cannot be performed by an ordinary grating. For diffraction, the grating element must be order of wavelength of light. The X-ray has wavelength of (1/100)th of ordinary visible light. So, for diffraction of X-ray crystal grating is needed.

ⓑ ⇒ Soln
here, $d = 1.1 \times 10^{-10}$ m, $\theta_1 = 5°$.
For the 1st order image, $n = 1$

$2d \sin\theta_n = n\lambda$

$2d \sin\theta_1 = 1 \times \lambda$

$\lambda = 2d \sin\theta_1 = 2 \times 1.1 \times 10^{-10} \sin 5°$

$= 0.2 \times 10^{-10}$ m

For the 2nd order image,

$2d \sin\theta_2 = 2\lambda$

$\sin\theta_2 = \frac{\lambda}{d} = \frac{0.2 \times 10^{-10}}{1.1 \times 10^{-10}} = 0.1818$

$\theta_2 = \sin^{-1}(0.1818) = 10.5°$.

Interpretation,

$2d \sin\theta_2 = 2\lambda$

$2 \times 1.1 \times 10^{-10} \sin(10.5) = 2 \times 0.2 \times 10^{-10}$

or $4 \times 10^{-11} = 4 \times 10^{-11}$

8ⓐ ⇒ In case of an unstable nucleus like that of radioactive elements, number of neutrons is more than that of number of protons. In beta (β) decay a neutron gets converted into a proton. It emits an electron at very high speed. So, the electron is created as a part of β decay and was not there since beginning.

ⓑ ⇒

n = unstable

$_0n^1 \longrightarrow {_1H^1} + {_{-1}e^-} + \bar{\nu}$

here, $e^- = \beta$

β^- decay

So, a nucleus contains no electrons, yet it eject them

(b)

⇒ Soln

Time (t) = 100 days

Half life $(T_{1/2})$ = ?

Let, A_0 and A be the initial and final activities respect

According to question

$A = (1\%\ of\ A_0) \frac{1}{10}$

$A = \frac{1}{100} A_0 \times \frac{1}{10}$

$\frac{A}{A_0} = \frac{1}{1000}$

Since, $A \propto N$

$\frac{A}{A_0} = \frac{N}{N_0} = e^{-\lambda t} \Rightarrow e^{-\lambda t} = \frac{1}{1000}$

$e^{\lambda t} = 1000$

$\lambda t = \ln(1000)$

$\lambda = \frac{1}{t} \ln(1000)$

$= \frac{1}{100} \ln(1000)$

$\therefore T_{1/2} = \frac{0.693}{\lambda} = \frac{0.693 \times 100}{\ln(1000)} = 10.03$ days

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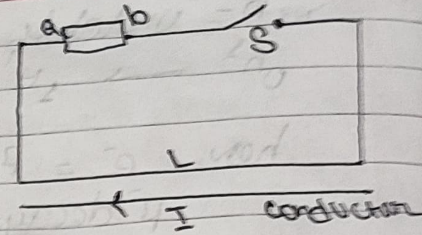
Group - C.

9(a)



(b)

⇒ Sol^n

given, line integral = $\int B.dl = 3.83 \times 10^{-4}$ Tm

Net current (I) = ?

we know

$$\int B dl = \mu_0 I$$

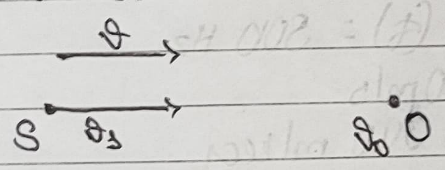
or $I = \frac{\int B dl}{\mu_0}$

$= \frac{3.83 \times 10^{-4}}{4\pi \times 10^{-7}} = 304.781$ A

10 (a) ⇒ The change in pitch produced due to relative motion of the source and the listener is known as Doppler's effect.

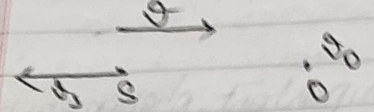
Doppler's effect is an important phenomenon in various scientific disciplines, including planetary science. This describes the changes in the frequency of any sound or light wave produced by a moving source with respect to an observer.
Waves emitted by a source travelling towards an observer gets compressed. In contrast, waves emitted by a source travelling away from an observer get stretched out. Christian Johann Doppler first proposed this effect in 1842.

(b) ⇒ When a source is moving towards an stationary observer.



Let S and O be the source and Observer respectively. And let, v be the velocity of the sound and v_s and v_0 be the velocity of source and velocity of observer respectively.
Here Observer is in stationary motion, so, $v_0 = 0$
Let f and f' be the frequency of the source and apparent frequency respectively
then,
for source,
$$\lambda' = \frac{v - v_s}{f}$$
for observer
$$f' = \frac{v}{\lambda'}$$
so,
$$\boxed{f' = \left(\frac{v}{v - v_s}\right) f}$$

When source is moving away from the stationary observer



For source

$$\lambda' = \frac{v + v_s}{f}$$

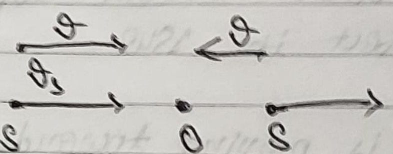
For observer

$$f' = \frac{v}{\lambda'}$$

$$\boxed{f' = \left(\frac{v}{v + v_s}\right) f}$$

(c)

⇒ Sol^n



The frequency of sound $(f) = 500$ Hz.
Speed of car $(v_s) = 20$ m/s
Velocity of sound $(v) = 340$ m/sec

Let f_1 and f_2 be the frequency of the sound heard by the observer when the car approaches and passes the stationary observer respectively

Then,

$$f_1 = \left(\frac{v}{v - v_s}\right) f = \left(\frac{340}{340 - 20}\right) 500$$

$$= \left(\frac{340}{320}\right) 500$$

$$= 531.25 \text{ Hz}$$

And,

$$f_2 = \left(\frac{v}{v + v_s}\right) f = \left(\frac{340}{340 + 20}\right) 500 = \left(\frac{340}{360}\right) 500 = 472.22 \text{ Hz}$$

$$\Delta f = f_1 - f_2 = 531.25 - 472.22 = 59.03 \text{ Hz}$$

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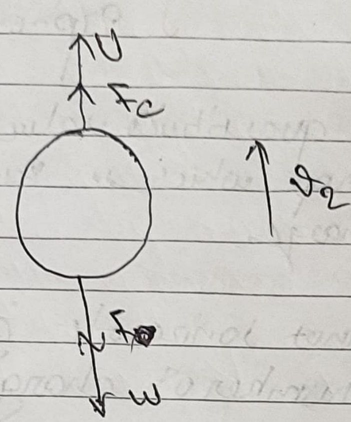
11 (a)

(i) => The principle that the charge of any ~~ob~~ object is an integer multiple of the elementary charge. Thus, an object's charge can be exactly 0e or exactly 1e, -1 e, 2e etc. but not 12e, or -1.8 e etc

(b) =>



~~Suppose the drop.~~
~~In absence of electric field, velocity of the drop be v_1 then~~

A strong electric field is applied between the plates in such a direction that force on the negatively charged oil drop starts moving upward and soon a terminal velocity v_2 in an upward direction.

Let E be the strength of the electric field. As the drop carries a charge Q, then electrostatic force on oil drop is

Upward direction $(F_e) = QE$

Viscous force in downward $(F) = 6\pi\eta r v_2$

$$w - U = \frac{4}{3}\pi r^3 (\rho - \sigma) g$$

when the oil drop attains terminal velocity v_2 then,

$$F_e + U = F + w$$

$$F_e = (F - U) + w$$

$$QE = \frac{4}{3}\pi r^3 (\rho - \sigma) g + 6\pi\eta r v_2$$

c (ii) $Q = \frac{6\pi\eta r v_1 + 6\pi\eta r v_2}{E}$

$Q = \frac{6\pi\eta r (v_1+v_2)}{E}$

$= \frac{6\pi\eta(v_1+v_2)}{E} \times \sqrt{\frac{9\eta v_1}{2(\rho-\sigma)g}}$ — (ii)

known all these quantities value we can get the charge of the drop which is known as quantization of charge.

11 a(ii) Visible light cannot ionize the gas in order to have a large number of charged oil drops.

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(c) (i) Weight of oil drop (m) = 2.0×10^{-15} kg
Potential difference (V) = 620 V.
distance between two plates (d) = ?
No. of electron (n) = 2.

If the drop is in equilibrium, then

$qE = mg$

$ne\left(\frac{V}{d}\right) = 2.0 \times 10^{-15} \times 10.$

or $2 \times 1.6 \times 10^{-19} \times \left(\frac{620}{d}\right) = 2.0 \times 10^{-15} \times 10$

$\frac{620}{d} = 62500$

$d = 9.92 \times 10^{-3}$ m

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OR (a)(i) According to Einsteins' photoelectric equation,

$$\frac{1}{2}mv_{max}^2 = h(f-f_0)$$

where, f is the frequency of incident light and f_0 is threshold frequency.

If the frequency of incident radiation is less the threshold frequency (i.e $f<f_0$), the K.E of photo electron is negative and hence the electron emission is not possible.

(ii) ⇒ Two other pieces of evidence provided by the photoelectric effect which suggest that electromagnetic radiation has particle properties are:-

(i) Rate of emission of electrons depends on intensity

(ii) maximum electron energy dependent on frequency

b(i)

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b (i) → Sol^n

given, work function $(\phi) = 3.8\,eV = 3.8 \times 1.6 \times 10^{-19}\,eV$

minimum frequency $(f_0) = ?$

we have,

$$f_0 = \frac{\phi}{h}$$

$$= \frac{3.8 \times 1.6 \times 10^{-19}}{6.626 \times 10^{-34}}$$

$$= 9.18 \times 10^{14}\ Hz.$$

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ⓒ ⇒ Any two applications of photoelectric effect in our daily life are:-
(i) Used to generate electricity with the help of solar panel.
(ii) In traffic controlling devices.

5 ⓐ ⇒ A shunt is connected in parallel with a galvanometer. If the resistance of shunt is very low, the effective resistance of the circuit will be minimum and it will allow to measure the net current flowing in the circuit with low voltage drop.
Hence, a shunt must have very low resistance.

ⓑ To increase the range of ammeter n times; the value of shunt required is

$$R_s = \frac{G}{n-1}$$

where, R_s = resistance of shunt
G = resistance of galvanometer

ⓒ If the galvanometer shows the deflection out of range in an experiment, then the result that can be drawn is the supplied value of current is more than the range of the galvanometer i.e. $I > I_g$

(1) Sol^n

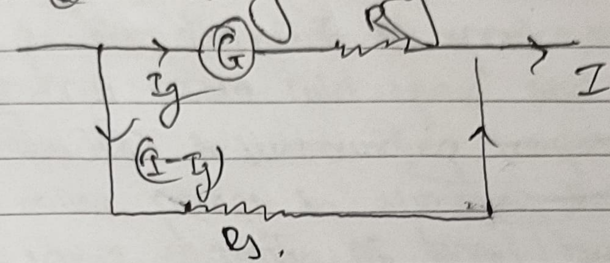
Resistance of galvanometer (G) = 10Ω

Range of Ammeter (I) = 1A.

Resistance of shunt (R_s) = 0.1Ω

Resistance in series with galvanometer (R) = 89.9Ω.

Full scale reading in galvanometer (I_g) = ?



here

The potential drop across R_s = Potential drop across (G+R)

$(I-I_g)R_s = I_g(G+R)$

or $(I-I_g)\,0.1 = I_g(10+89.9)$

or $0.1 - 0.1I_g = I_g \times 99.9$

or $\frac{0.1}{100} = I_g$

$\therefore I_g = 0.001$ A

Hence, the full scale reading in galvanometer is 0.001 A.