26th Feb. 2021 | Shift - 1
PHYSICS

JEE I NEET I Foundation

SECTION - A

1. If λ_1 and λ_2 are the wavelengths of the third member of Lyman and first member of the Paschen series respectively, then the value of $\lambda_1 : \lambda_2$ is :

(1) 1 : 3 (2) 1 : 9 (3) 7 : 135 (4) 7 : 108

Sol. (3)

For Lyman series

$n_1 = 1, \quad n_2 = 4$

$$\frac{1}{\lambda_1} = Rz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{1}{\lambda_1} = Rz^2\left(\frac{1}{1_1^2} - \frac{1}{4^2}\right)$$

$$\frac{1}{\lambda_1} = \frac{15Rz^2}{16}$$

$$\lambda_1 = \frac{16}{15Rz^2}$$

For paschen series

$n_1 = 3, \quad n_2 = 4$

$$\frac{1}{\lambda_2} = Rz^2\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$$

$$\frac{1}{\lambda_2} = Rz^2\left(\frac{16-9}{9\times16}\right)$$

$$\frac{1}{\lambda_2} = Rz^2\left(\frac{7}{9\times16}\right)$$

$$\lambda_2 = \frac{9\times16}{7Rz^2}$$

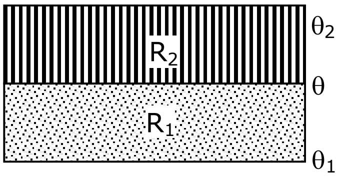
So,

$$\frac{\lambda_1}{\lambda_2} = \frac{\frac{16}{15Rz^2}}{\frac{9\times16}{7Rz^2}}$$

$$= \frac{16\times7}{15\times9\times16}$$

$$= \frac{7}{135}$$

2. The temperature θ at the junction of two insulating sheets, having thermal resistances R_1 and R_2 as well as top and bottom temperatures θ_1 and θ_2 (as shown in figure) is given by :



(1) $\frac{\theta_1 R_2 + \theta_2 R_1}{R_1 + R_2}$ (2) $\frac{\theta_1 R_2 - \theta_2 R_1}{R_2 - R_1}$ (3) $\frac{\theta_2 R_2 - \theta_1 R_1}{R_2 - R_1}$ (4) $\frac{\theta_1 R_1 + \theta_2 R_2}{R_1 + R_2}$

Sol. **(1)**

Temperature at the junction is θ.

so using the formula

$$\frac{T_2 - T}{R_1} = \frac{T - T_1}{R_2}$$

$$\frac{\theta_2 - \theta}{R_2} = \frac{\theta - \theta_1}{R_1}$$

$$R_1(\theta_2 - \theta) = R_2(\theta - \theta_1)$$

$$R_1\theta_2 - R_1\theta = R_2\theta - R_2\theta_1$$

$$R_1\theta + R_2\theta = R_1\theta_2 + R_2\theta_1$$

$$\theta = \frac{R_1\theta_2 + R_2\theta_1}{R_1 + R_2}$$

3. In a Young's double slit experiment two slits are separated by 2 mm and the screen is placed one meter away. When a light of wavelength 500 nm is used, the fringe separation will be :

(1) 0.75 mm (2) 0.50 mm (3) 1 mm (4) 0.25 mm

Sol. **(4)**

Fringe width (β) = $\frac{\lambda D}{d}$

$d = 2\times10^{-3}$m

$\lambda = 500\times10^{-9}$m

$D = 1$m

Now

$$\beta = \frac{500\times10^{-9}\times1}{2\times10^{-3}}$$

$$\beta = \frac{5}{2}\times10^{-4}$$

$$\beta = 2.5 \times 10^{-4}$$

$$\beta = 0.25 \text{ mm}$$

4. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : An electron microscope can achieve better resolving power than an optical microscope.

Reason R : The de Broglie's wavelength of the electrons emitted from an electron gun is much less than wavelength of visible light.

In the light of the above statements, choose the correct answer from the options given below:

(1) A is true but R is false.

(2) Both A and R are true but R is NOT the correct explanation of A.

(3) Both A and R are true and R is the correct explanation of A.

(4) A is false but R is true.

Sol. **(3)**

Resolution limit $(\Delta\theta) = \frac{1.22\lambda}{d}$

Resolution power $= \frac{1}{\text{Resolution limit}}$

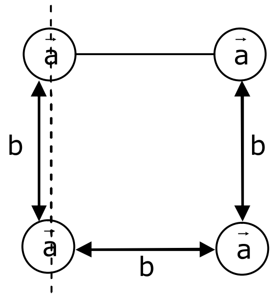
$\lambda \downarrow \Delta\theta\downarrow$

$\Delta\theta\downarrow$ Power $\uparrow$

5. Four identical solid spheres each of mass 'm' and radius 'a' are placed with their centres on the four corners of a square of side 'b'. The moment of inertia of the system about one side of square where the axis of rotation is parallel to the plane of the square is :

(1) $\frac{4}{5}ma^2$ (2) $\frac{8}{5}ma^2 + mb^2$ (3) $\frac{4}{5}ma^2 + 2mb^2$ (4) $\frac{8}{5}ma^2 + 2mb^2$

Sol. **(4)**



$$I = \frac{2}{5}ma^2 + \frac{2}{5}ma^2 + \left[\frac{2}{5}ma^2 + mb^2\right] + \frac{2}{5}ma^2 + mb^2$$

$$I = 4 \times \frac{2}{5}ma^2 + 2mb^2$$

$$= \frac{8}{5}ma^2 + 2mb^2$$

6. The normal density of a material is ρ and its bulk modulus of elasticity is K. The magnitude of increase in density of material, when a pressure P is applied uniformly on all sides, will be :

(1) $\frac{\rho K}{P}$ (2) $\frac{K}{\rho P}$ (3) $\frac{PK}{\rho}$ (4) $\frac{\rho P}{K}$

Sol. (4)

Bulk modulus $K = \frac{-\Delta P}{\frac{\Delta v}{v}} = \frac{-\Delta p v}{\Delta v}$

We know, $\rho = \frac{M}{V}$

So, $\frac{-\Delta\rho}{\rho} = \frac{\Delta v}{v}$

$$K = \frac{-\Delta P}{\left(-\frac{\Delta\rho}{\rho}\right)} = \frac{\rho\Delta P}{\Delta\rho}$$

$$\Delta\rho = \frac{\rho\Delta P}{K}$$

$$\Delta\rho = \frac{\rho P}{K}$$

7. LED is constructed from Ga-As-P semiconducting material. The energy gap of this LED is 1.9 eV. Calculate the wavelength of light emitted and its colour.
[$h=6.63\times10^{-34}$ Js and $c=3\times10^{8}$ ms^{-1}]

(1) 654 nm and red colour (2) 1046 nm and blue colour
(3) 1046 nm and red colour (4) 654 nm and orange colour

Sol. (1)

We know that $E = \frac{hc}{\lambda}$

$$\lambda = \frac{hc}{E} \Rightarrow \frac{1240(\text{in eV})}{E\ (\text{in eV})}$$

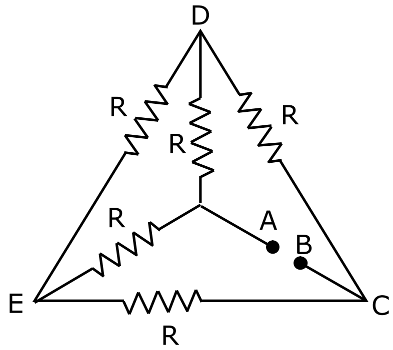
$$\lambda = \frac{1240}{1.9}$$

$= 652.63$ nm ≈ 654 nm

Wavelength of red light is 620 nm to 750 nm

So, answer is 1.

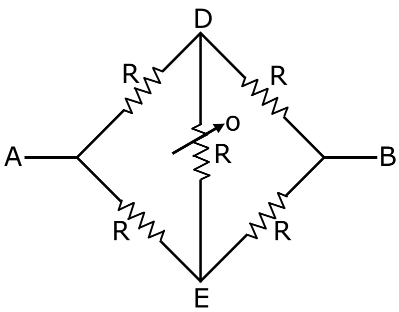
8. Five equal resistances are connected in a network as shown in figure. The net resistance between the points A and B is :



(1) $\frac{3R}{2}$ (2) $\frac{R}{2}$ (3) R (4) 2R

Sol. **(3)**

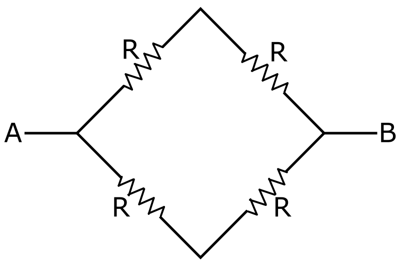
It is balanced wheat stone bridge

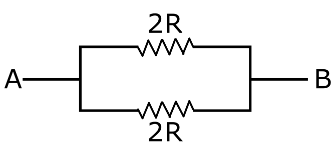


So, we know that

$$R_1R_4 = R_2R_3$$

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

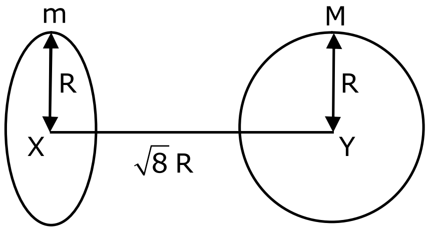




$$\text{Req} = \frac{2R \times 2R}{2R + 2R}$$

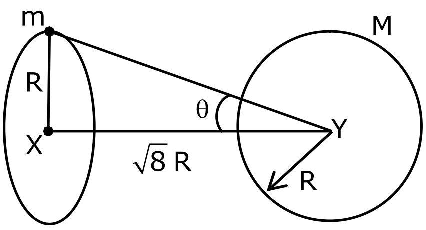
$$= \frac{4R^2}{4R} \Rightarrow R$$

9. Find the gravitational force of attraction between the ring and sphere as shown in the diagram, where the plane of the ring is perpendicular to the line joining the centres. If $\sqrt{8}R$ is the distance between the centres of a ring (of mass 'm') and a sphere (mass 'M') where both have equal radius 'R'.



(1) $\frac{\sqrt{8}}{9}\cdot\frac{GmM}{R}$ (2) $\frac{\sqrt{8}}{27}\cdot\frac{GmM}{R^2}$ (3) $\frac{2\sqrt{2}}{3}\cdot\frac{GMm}{R^2}$ (4) $\frac{1}{3\sqrt{8}}\cdot\frac{GMm}{R^2}$

Sol. **(2)**



We know that

$$F = ME = M\left(\frac{GM\sqrt{8}R}{\left(R^2+(\sqrt{8}R)^2\right)^{3/2}}\right)$$

$$F = \frac{GMm\sqrt{8}R}{\left(9R^2\right)^{3/2}} \Rightarrow \frac{2\sqrt{2}GmM}{\left(9R^2\right)^{3/2}}$$

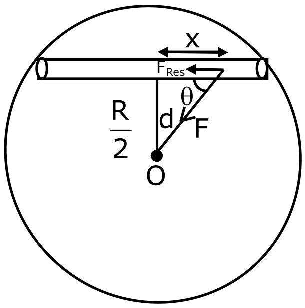
$$= \frac{2\sqrt{2}GmM}{27R^2}$$

$$F = \frac{\sqrt{8}GMm}{27R^2}$$

10. Assume that a tunnel is dug along a chord of the earth, at a perpendicular distance (R/2) from the earth's centre, where 'R' is the radius of the Earth. The wall of the tunnel is frictionless. If a particle is released in this tunnel, it will execute a simple harmonic motion with a time period :

(1) $2\pi\sqrt{\frac{R}{g}}$ (2) $\frac{1}{2\pi}\sqrt{\frac{g}{R}}$ (3) $\frac{2\pi R}{g}$ (4) $\frac{g}{2\pi R}$

Sol. (1)



$$\cos\theta = \frac{x}{d}$$

If displaced from equilibrium position,

$$F_{restoring} = \left(\frac{GMmd}{R^3}\right)\cos\theta$$

$$F_{Res.} = \frac{GMmd}{R^3}\cdot\frac{x}{d} = \frac{GMmx}{R^3}$$

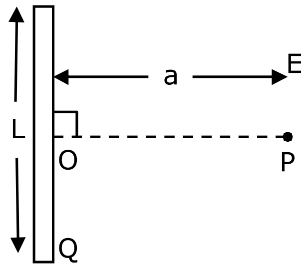
$$a_R = \frac{GMx}{R^3} \qquad GM_e = gR^2$$

$$T = 2\pi\sqrt{\left|\frac{x}{a}\right|}$$

$$T = 2\pi\sqrt{\frac{x}{\frac{GMx}{R^3}}}\sqrt{\frac{R^3}{gR^2}}$$

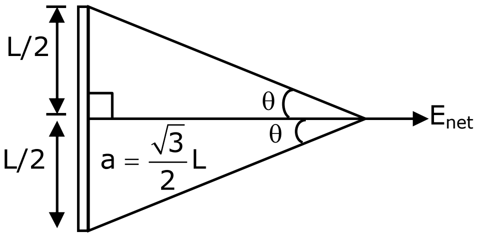
$$\boxed{T = 2\pi\sqrt{\frac{R}{g}}}$$

11. Find the electric field at point P (as shown in figure) on the perpendicular bisector of a uniformly charged thin wire of length L carrying a charge Q. The distance of the point P from the centre of the rod is $a = \frac{\sqrt{3}}{2}L$.



(1) $\frac{Q}{2\sqrt{3}\pi\varepsilon_0 L^2}$ (2) $\frac{\sqrt{3}Q}{4\pi\varepsilon_0 L^2}$ (3) $\frac{Q}{3\pi\varepsilon_0 L^2}$ (4) $\frac{Q}{4\pi\varepsilon_0 L^2}$

Sol. **(1)**



$$\tan\theta = \frac{L/2}{\frac{\sqrt{3}}{2}L} \Rightarrow \frac{1}{\sqrt{3}}$$

$\theta = 30°$

$$E_{net} = \frac{K\lambda}{\frac{\sqrt{3}}{2}L}(\sin 30° + \sin 30°) \Rightarrow \frac{2KQ}{\sqrt{3}L^2}\left(\frac{1}{2}+\frac{1}{2}\right)$$

$$E_{net} = \frac{1}{4\pi\varepsilon_0}\frac{2Q}{\sqrt{3}L^2}$$

$$E_{net} = \frac{Q}{2\sqrt{3}\pi\varepsilon_0 L^2}$$

12. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

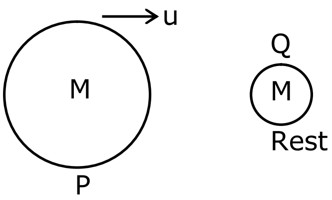
Assertion A : Body 'P' having mass M moving with speed 'u' has head-on collision elastically with another body 'Q' having mass 'm' initially at rest. If m<<M, body 'Q' will have a maximum speed equal to '2u' after collision.

Reason R : During elastic collision, the momentum and kinetic energy are both conserved.

In the light of the above statements, choose the most appropriate answer from the options given below:

(1) A is correct but R is not correct.
(2) Both A and R are correct but R is NOT the correct explanation of A.
(3) A is not correct but R is correct.
(4) Both A and R are correct and R is the correct explanation of A.

Sol. **(4)**



m << M

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

For elastic collision $\rightarrow$ e = 1

$$1 = \frac{v_2 - u}{u - 0}$$

$u = v_2 - u$

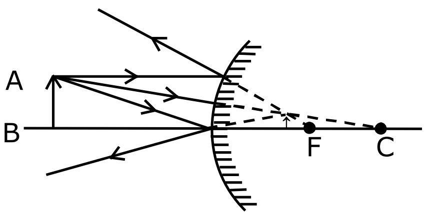
$$\boxed{v_2 = 2u}$$

In elastic collision kinetic energy & momentum are conserved.

13. A short straight object of height 100 cm lies before the central axis of a spherical mirror whose focal length has absolute value $|f|$ = 40 cm. The image of object produced by the mirror is of height 25 cm and has the same orientation of the object. One may conclude from the information :

(1) Image is real, same side of concave mirror.
(2) Image is virtual, opposite side of convex mirror.
(3) Image is virtual, opposite side of concave mirror.
(4) Image is real, same side of convex mirror.

Sol. **(2)**



Same orientation so image is virtual. It is combination of real object and virtual image using height it is possible only from convex mirror.

14. A particle is moving with uniform speed along the circumference of a circle of radius R under the action of a central fictitious force F which is inversely proportional to R^3. Its time period of revolution will be given by :

(1) $T \propto R^{\frac{5}{2}}$ (2) $T \propto R^2$ (3) $T \propto R^{\frac{4}{3}}$ (4) $T \propto R^{\frac{3}{2}}$

Sol. **(2)**

$$F \propto \frac{1}{R^3}$$

$$F = \frac{K}{R^3}$$

$$\frac{mv^2}{R} = \frac{K}{R^3}$$

$$m(\omega R)^2 = \frac{K}{R^2}$$

$$m\omega^2R^2 = \frac{K}{R^2}$$

$$\omega^2 = \frac{K}{m}\left(\frac{1}{R^4}\right)$$

$$\left(\frac{2\pi}{T}\right)^2 \propto \frac{1}{R^4}$$

$$\frac{4\pi^2}{T^2} \propto \frac{1}{R^4}$$

$$\boxed{T \propto R^2}$$

15. A large number of water drops, each of radius r, combine to have a drop of radius R. If the surface tension is T and mechanical equivalent of heat is J, the rise in heat energy per unit volume will be :

(1) $\frac{2T}{rJ}$ (2) $\frac{3T}{rJ}$ (3) $\frac{2T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$ (4) $\frac{3T}{J}\left(\frac{1}{r}-\frac{1}{R}\right)$

Sol. **(4)**

R is the radius of bigger drop.
r is the radius of n water drops.
Water drops are combined to make bigger drop.
So,

Volume of n drops = volume of bigger drop

$$n\left(\frac{4}{3}\pi r^3\right) = \frac{4}{3}\pi R^3$$

$$R = rn^{1/3} \Rightarrow n = \left(\frac{R}{r}\right)^3$$

$\Delta U = T$(Change in surface area)
$\Delta U = T(n4\pi r^2 - 4\pi R^2)$

$$\Delta U = 4\pi T\left[\left(\frac{R}{r}\right)^3 r^2 - R^2\right] \Rightarrow \frac{4\pi T\left(\frac{R^3}{r} - R^2\right)}{J}$$

$$\frac{\Delta U}{V} = \frac{4\pi T\left(\frac{R^3}{r} - R^2\right)}{J \times \frac{4}{3}\pi R^3} = \frac{3T}{J}\left[\frac{1}{r} - \frac{1}{R}\right]$$

16. A planet revolving in elliptical orbit has :
A. a constant velocity of revolution.
B. has the least velocity when it is nearest to the sun.
C. its areal velocity is directly proportional to its velocity.
D. areal velocity is inversely proportional to its velocity.
E. to follow a trajectory such that the areal velocity is constant.
Choose the correct answer from the options given below :
(1) A only (2) E only (3) D only (4) C only

Sol. **(2)**

$$\boxed{\frac{d\vec{A}}{dt} = \frac{\vec{L}}{2m}}$$

17. An alternating current is given by the equation $i=i_1\sin\omega t + i_2\cos\omega t$. The rms current will be :
(1) $\frac{1}{2}\left(i_1^2+i_2^2\right)^{\frac{1}{2}}$ (2) $\frac{1}{\sqrt{2}}\left(i_1^2+i_2^2\right)^{\frac{1}{2}}$ (3) $\frac{1}{\sqrt{2}}\left(i_1+i_2\right)^2$ (4) $\frac{1}{\sqrt{2}}\left(i_1+i_2\right)$

Sol. **(2)**

$$I_0 = \sqrt{I_1^2 + I_2^2 + 2I_1I_2\cos\theta}$$
$$I_0 = \sqrt{I_1^2 + I_2^2 + 2I_1I_2\cos 90^\circ}$$
$$I_0 = \sqrt{I_1^2 + I_2^2 + 2I_1I_2(0)} \Rightarrow \sqrt{I_1^2 + I_2^2}$$

We , know that

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

So, $$I_{rms} = \frac{\sqrt{I_1^2 + I_2^2}}{\sqrt{2}}$$

18. Consider the combination of 2 capacitors C_1 and C_2, with $C_2>C_1$, when connected in parallel, the equivalent capacitance is $\frac{15}{4}$ times the equivalent capacitance of the same connected in series. Calculate the ratio of capacitors, $\frac{C_2}{C_1}$.
(1) $\frac{15}{11}$ (2) $\frac{29}{15}$ (3) $\frac{15}{4}$ (4) $\frac{111}{80}$

Sol. **Bonus**

$$C_1 + C_2 = \frac{15}{4}\left(\frac{C_1C_2}{C_1+C_2}\right)$$
$$4(C_1 + C_2)^2 = 15C_1C_2$$
$$4C_1^2 + 4C_2^2 - 7C_1C_2 = 0$$
$$4 + 4\left(\frac{C_2}{C_1}\right)^2 - 7\frac{C_2}{C_1} = 0$$
$$4\left(\frac{C_2}{C_1}\right)^2 - 7\frac{C_2}{C_1} + 4 = 0$$

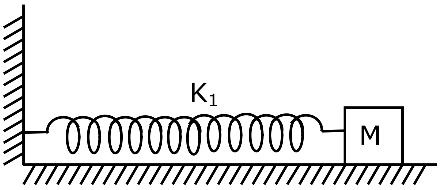
$\frac{C_2}{C_1}$ has not real value

$\frac{C_2}{C_1}$ = imaginary

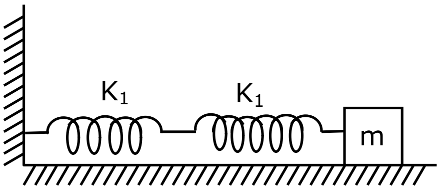
19. If two similar springs each of spring constant K_1 are joined in series, the new spring constant and time period would be changed by a factor :

(1) $\frac{1}{2}, \sqrt{2}$ (2) $\frac{1}{4}, 2\sqrt{2}$ (3) $\frac{1}{2}, 2\sqrt{2}$ (4) $\frac{1}{4}, \sqrt{2}$

Sol. **(1)**



$$T = 2\pi\sqrt{\frac{m}{K_1}}$$



$$K_{eq} = \frac{K_1 \times K_1}{K_1 + K_1} = \frac{K_1^2}{2K_1}$$

$$K_{eq} = \frac{K_1}{2}$$

$$T' = 2\pi\sqrt{\frac{m}{K_{eq}}} = 2\pi\sqrt{\frac{m}{\frac{k_1}{2}}}$$

$$= \sqrt{2}T$$

20. In a typical combustion engine the workdone by a gas molecule is given by $W = \alpha^2\beta e^{\frac{-\beta x^2}{kT}}$, where x is the displacement, k is the Boltzmann constant and T is the temperature. If α and β are constants, dimensions of α will be :

(1) $[M^0 L T^0]$ (2) $[M^2 L T^{-2}]$ (3) $[M L T^{-2}]$ (4) $[M L T^{-1}]$

Sol. **(1)**

$\frac{\beta x^2}{KT}$ is dimension less

so

$$KT = \beta x^2 \quad \Rightarrow M^1L^2T^{-2}$$

$$\beta = \frac{M^1L^2T^{-2}}{L^2} \quad \Rightarrow M^1T^{-2}$$

$$M^1L^2T^{-2} = \alpha^2 M^1T^{-2}$$

$$\alpha^2 = L^2$$

$$\alpha = L$$

$$\alpha = M^0L^1T^0$$

SECTION - B

1. The mass per unit length of a uniform wire is 0.135 g/cm. A transverse wave of the form y=−0.21sin(x+30t) is produced in it, where x is in meter and t is in second. Then, the expected value of tension in the wire is x × 10^{-2} N. Value of x is __________. (Round-off to the nearest integer)

Sol. **1215**

$y = -0.21\sin(x+30t)$

$v = \frac{\omega}{K} = \frac{30}{1} = 30\text{m/s}$

$v = \sqrt{\frac{T}{\mu}}$

$T = v^2 \times \mu$

$T = (30)^2 \times 0.135 \times 10^{-1}$ $\qquad \mu = 0.135\text{gm/cm}$

$T = 900 \times 0.135 \times 10^{-1}$ $\qquad \mu = 0.135 \times \frac{10^{-3}}{10^{-2}}\frac{\text{kg}}{\text{m}}$

$T = 12.15\text{N}$

$T = 1215 \times 10^{-2}\text{ N}$

$\boxed{x = 1215}$

2. A radiation is emitted by 1000 W bulb and it generates an electric field and magnetic field at P, placed at a distance of 2m. The efficiency of the bulb is 1.25%. The value of peak electric field at P is x × 10^{-1} V/m. Value of x is __________. (Rounded-off to the nearest integer)
[Take $\varepsilon_0 = 8.85\times10^{-12}\ C^2\ N^{-1}\ m^{-2}$, $c=3\times10^8\ ms^{-1}$]

Sol. **137**

Intensity of electro magnetic wave is,

$$I = \frac{1}{2}c\varepsilon_0 E_0^2 = \frac{P}{4\pi r^2}$$

$$\frac{1}{2}4\pi\varepsilon_0 \times c \times E_0^2 = \frac{P}{r^2}$$

$$\frac{1}{2}\times\frac{3\times10^5\times E_0^2}{9\times10^9} = \frac{1000\times1.25}{(2)^2}\times\frac{1}{100}$$

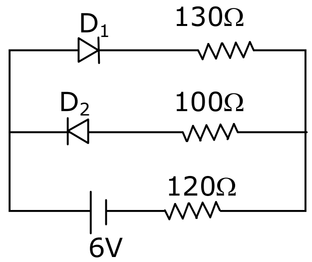
$$E_0^2 = \frac{60\times1000\times1.25}{4\times100} = \frac{125\times3}{2}$$

$$E_0^2 = \frac{375}{2} = 187.5$$

$$\boxed{E_0 = 13.69}$$

$$E_0 \approx 137\times10^{-1}\ \text{v/m}$$

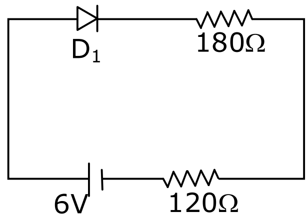
3. The circuit contains two diodes each with a forward resistance of 50Ω and with infinite reverse resistance. If the battery voltage is 6 V, the current through the 120 Ω resistance is __________ mA.



Sol. **20**

D_2 is reverse bias so current does not flow through D_2.

D_1 is forward bias.

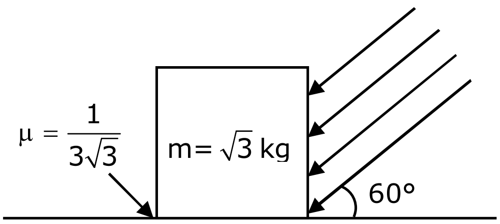


$I = \frac{6}{300}$ $\Rightarrow 0.02$ A

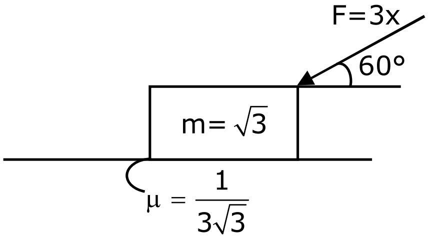
= 20 mA

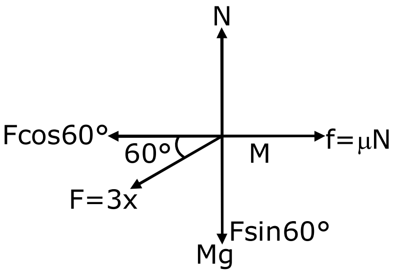
4. As shown in the figure, a block of mass $\sqrt{3}$ kg is kept on a horizontal rough surface of coefficient of friction $\frac{1}{3\sqrt{3}}$. The critical force to be applied on the vertical surface as shown at an angle 60° with horizontal such that it does not move, will be 3x. The value of x will be ________.

[g=10m/s^2; sin 60°=$\frac{\sqrt{3}}{2}$; cos 60°=$\frac{1}{2}$]



Sol. **3.33**





N = Mg + Fsin60°

$N = \sqrt{3}g + \frac{F\sqrt{3}}{2}$

For No slipping

Fcos60° = Friction

$\frac{F}{2} = \mu N = \frac{1}{3\sqrt{3}}\left(\sqrt{3}g + \frac{F\sqrt{3}}{2}\right)$

$\frac{F}{2} = \frac{g}{3} + \frac{F}{6}$

$\frac{F}{2} - \frac{F}{6} = \frac{g}{3}$

$\frac{6F - 2F}{12} = \frac{g}{3}$

4F = 4g

F = 10

F = 3x

$x = \frac{F}{3} = \frac{10}{3} = 3.33$

$\boxed{x = 3.33}$

5. In a series LCR resonant circuit, the quality factor is measured as 100. If the inductance is increased by two fold and resistance is decreased by two fold, then the quality factor after this change will be ___________.

Sol. 282.84

Quality factor $= \frac{X_L}{R} = \frac{\omega L}{R}$

$$Q = \frac{1}{\sqrt{LC}}\frac{L}{R}$$

$$Q = \left(\frac{1}{\sqrt{C}}\right)\frac{\sqrt{L}}{R}$$

$$Q = \frac{XL}{R} = \frac{\omega L}{R} = \frac{1}{\sqrt{LC}}\frac{L}{R} = \frac{1}{R}\frac{\sqrt{L}}{\sqrt{C}}$$

$$Q' = \frac{\sqrt{2L}}{\left(\frac{R}{2}\right)\sqrt{C}} = 2\sqrt{2}Q$$

$$\boxed{Q' = 282.84}$$

6. In an electrical circuit, a battery is connected to pass 20 C of charge through it in a certain given time. The potential difference between two plates of the battery is maintained at 15 V. The work done by the battery is ___________ J.

Sol. 300

Charge flown (Q) = 20 C
Potential difference (V) = 15V
Work done (w) = Q.V
= 20 × 15 = 300 J

$$\boxed{w = 300\ J}$$

7. A container is divided into two chambers by a partition. The volume of first chamber is 4.5 litre and second chamber is 5.5 litre. The first chamber contain 3.0 moles of gas at pressure 2.0 atm and second chamber contain 4.0 moles of gas at pressure 3.0 atm. After the partition is removed and the mixture attains equilibrium, then, the common equilibrium pressure existing in the mixture is $x \times 10^{-1}$ atm. Value of x is ________.

Sol. 25

By energy Conservation

$$\frac{3}{2}n_1RT_1 + \frac{3}{2}n_2RT_2 = \frac{3}{2}(n_1 + n_2)RT$$

Using PV = nRT

$$P_1V_1 + P_2V_2 = P(V_1 + V_2)$$

$$P = \frac{P_1V_1 + P_2V_2}{V_1 + V_2} = \frac{2 \times 4.5 + 3 \times 5.5}{4.5 + 5.5}$$

$$P = \frac{9 + 16.5}{10} = \frac{25.5}{10}$$

$\approx 25 \times 10^{-1}$ atm

8. A boy pushes a box of mass 2kg with a force $\vec{F} = \left(20\hat{i} + 10\hat{j}\right)$ N on a frictionless surface. If the box was initially at rest, then __________m is displacement along the x-axis after 10 s.

Sol. **500**

$F = 20\hat{i} + 10\hat{j}$

$F_x = 20N$

$F_y = 10N$

$$a_x = \frac{F_x}{M} = \frac{20}{2} = 10\ m/s^2$$

$$a_y = \frac{F_y}{M} = \frac{10}{2} = 5\ m/s^2$$

displacement on x axis is

$$S_x = u_x t + \frac{1}{2}a_x t^2$$

$$S = 0 \times 10 + \frac{1}{2} \times 10 \times (10)^2$$

$$\boxed{S = 500\,m}$$

9. The maximum and minimum amplitude of an amplitude modulated wave is 16 V and 8 V respectively. The modulation index for this amplitude modulated wave is x $\times 10^{-2}$. The value of x is ________.

Sol. **33**

$$A_m = \frac{A_{max} - A_{min}}{2}$$

$$A_C = \frac{A_{max} + A_{min}}{2} \qquad \begin{bmatrix} A_{max} = 16V \\ A_{min} = 8V \end{bmatrix}$$

$$\text{Modulation index (mi)} = \frac{A_m}{A_C} = \frac{\frac{A_{max} - A_{min}}{2}}{\frac{A_{max} + A_{min}}{2}} = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$$

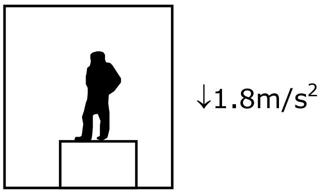
$$mi = \frac{16-8}{16+8} = \frac{8}{24} = \frac{1}{3} = 0.33$$

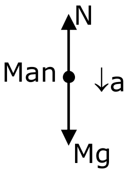
$$mi = 33 \times 10^{-2}$$

$$\boxed{x = 33}$$

10. A person standing on a spring balance inside a stationary lift measures 60 kg. The weight of that person if the lift descends with uniform downward acceleration of 1.8 m/s^2 will be ___________ N. [$g = 10 m/s^2$]

Sol. **492**





$Mg - N = Ma$

$N = M(g-a)$

$N = 60(10-1.8)$

$N = 60 \times 8.2 = 492N$

$\boxed{N = 492}$