JEE MAINS 2018 15TH APRIL 2018 MORNING SHIFT PHYSICS

1. *A, B, C* and *D* are four different physical quantities having different dimensions. None of them is dimensionless. But we know that the equation $AD = C\ln(BD)$ holds true. Then which of the combination is not a meaningful quantity?

(1) $A^2 - B^2C^2$

(2) $\frac{(A-C)}{D}$

(3) $\frac{A}{B} - C$

(4) $\frac{C}{BD} - \frac{AD^2}{C}$

2. A particle of mass *M* is moving in a circle of fixed radius *R* in such a way that its centripetal acceleration at time *t* is given by n^2Rt^2 where *n* is a constant. The power delivered to the particle by the force acting on it, is :

(1) Mn^2R^2t

(2) MnR^2t

(3) MnR^2t^2

(4) $\frac{1}{2}Mn^2R^2t^2$

3. Concrete mixture is made by mixing cement, stone and sand in a rotating cylindrical drum. If the drum rotates too fast, the ingredients remain stuck to the wall of the drum and proper mixing of ingredients does not take place. The maximum rotational speed of the drum in revolutions per minute(rpm) to ensure proper mixing is close to :

(Take the radius of the drum to be 1.25 m and its axle to be horizontal) :

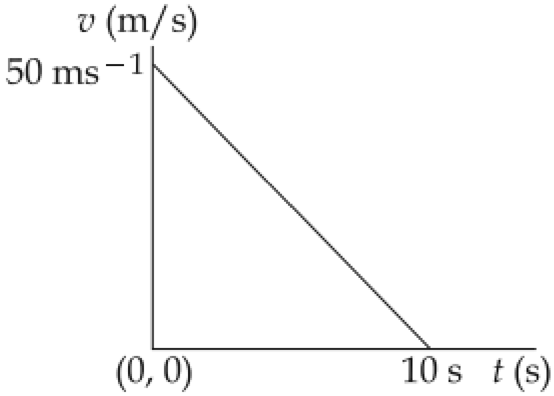
(1) 0.4

(2) 1.3

(3) 8.0

(4) 27.0

4. Velocity-time graph for a body of mass 10 kg is shown in figure. Work-done on the body in first two seconds of the motion is :



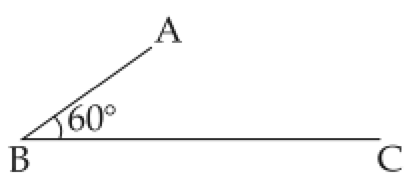
(1) 12000 J

(2) -12000 J

(3) -4500J

(4) -9300 J

5. In the figure shown ABC is a uniform wire. If centre of mass of wire lies vertically below point A, then $\frac{BC}{AB}$ is close to:



(1) 1.85

(2) 1.37

(3) 1.5

(4) 3

6. An astronaut of mass *m* is working on a satellite orbiting the earth at a distance *h* from the earth's surface. The radius of the earth is *R*, while its mass is *M*. The gravitational pull F_G on the astronaut is :

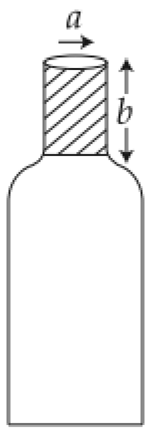
(1) Zero since astronaut feels weightless

(2) $0 < F_G < \frac{GMm}{R^2}$

(3) $\frac{GMm}{(R+h)^2} < F_G < \frac{GMm}{R^2}$

(4) $F_G = \frac{GMm}{(R+h)^2}$

7. A bottle has an opening of radius *a* and length *b*. A cork of length *b* and radius $(a + \Delta a)$ where $(a + \Delta a)$ is compressed to fit into the opening completely (See figure). If the bulk modulus of cork is B and frictional coefficient between the bottle and cork is μ then the force needed to push the cork into the bottle is :



(1) $(\pi\mu Bb)\Delta a$

(2) $(2\pi\mu Bb)\Delta a$

(3) $(\pi\mu Bb)a$

(4) $(4\pi\mu Bb)\Delta a$

8. A Carnot freezer takes heat from water at 0°C inside it and rejects it to the room at a temperature of 27°C. The latent heat of ice is 336×10^{3} J kg^{-1}. If 5 kg of water at 0°C is converted into ice at 0°C by the freezer, then the energy consumed by the freezer is close to :

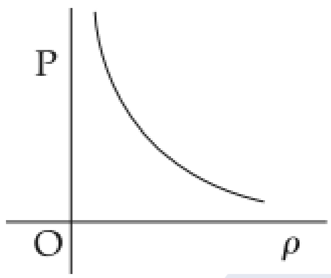
(1) 1.67×10^{5} J

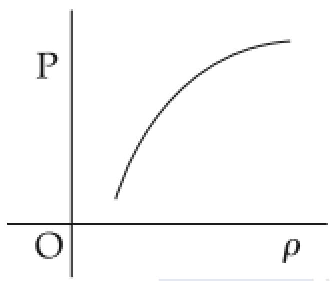
(2) 1.68×10^{6} J

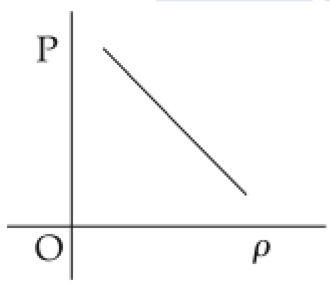
(3) 1.51×10^{5} J

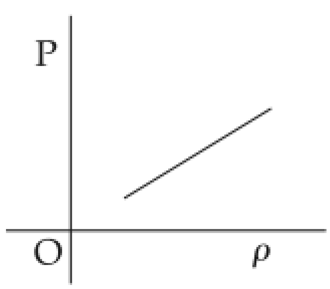
(4) 1.71×10^{7} J

9. Which of the following shows the correct relationship between the pressure ‘P’ and density ρ of an ideal gas at constant temperature?

(1) 

(2) 

(3) 

(4) 

10. In an engine the piston undergoes vertical simple harmonic motion with amplitude 7 cm. A washer rests on top of the piston and moves with it. The motor speed is slowly increased. The frequency of the piston at which the washer no longer stays in contact with the piston, is close to :

(1) 0.1 Hz

(2) 1.2 Hz

(3) 0.7 Hz

(4) 1.9 Hz

11. A toy-car, blowing its horn, is moving with a steady speed of 5 m/s, away from a wall. An observer, towards whom the toy car is moving, is able to hear 5 beats per second. If the velocity of sound in air is 340 m/s, the frequency of the horn of the toy car is close to :

(1) 680 Hz

(2) 510 Hz

(3) 340 Hz

(4) 170 Hz

12. Within a spherical charge distribution of charge density *ρ(r)*, *N* equipotential surfaces of potential $V_0, V_0+\Delta V, V_0+2\Delta V, ...\ V\ 0+N\Delta V\ \left(\Delta V>0\right)$, are drawn and have increasing radii $r_0, r_1, r_2, ...r_N$, respectively. If the difference in the radii of the surfaces is constant for all values of V_0 and ΔV then :

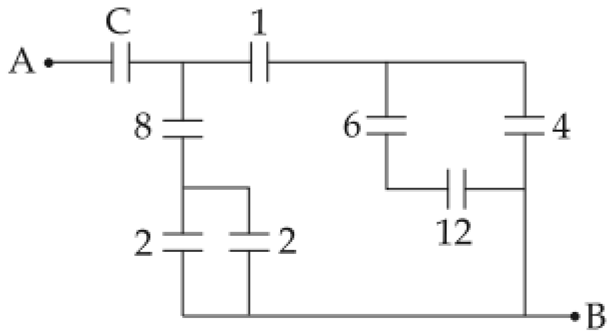
(1) $\rho(r)\alpha r$

(2) $\rho(r) = \text{constant}$

(3) $\rho(r)\alpha\frac{1}{r}$

(4) $\rho(r)\alpha\frac{1}{r^2}$

13. Figure shows a network of capacitors where the numbers indicates capacitances in micro Farad. The value of capacitance C if the equivalent capacitance between point A and B is to be 1 μF is :



(1) $\frac{31}{23}\mu F$

(2) $\frac{32}{23}\mu F$

(3) $\frac{33}{23}\mu F$

(4) $\frac{34}{23}\mu F$

14. The resistance of an electrical toaster has a temperature dependence given by $R(T)=R_0[1+\alpha(T-T_0)]$ in its range of operation. At T_0=300 K, R=100 Ω and at T=500 K, R=120 Ω. The toaster is connected to a voltage source at 200 V and its temperature is raised at a constant rate from 300 to 500 K in 30 s. The total work done in raising the temperature is :

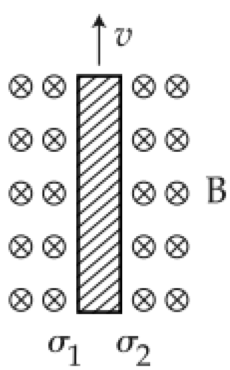
(1) $400 \ln\frac{1.5}{1.3}$ J

(2) $200 \ln \frac{2}{3}$ J

(3) $400 \ln \frac{5}{6}$ J

(4) 300 J

15. Consider a thin metallic sheet perpendicular to the plane of the paper moving with speed 'v' in a uniform magnetic field B going into the plane of the paper (See figure). If charge densities σ_1 and σ_2 are induced on the left and right surfaces, respectively, of the sheet then (ignore fringe effects) :



(1) $\sigma_1 = \varepsilon_0 vB, \sigma_2 = -\varepsilon_0 vB$

(2) $\sigma_1 = \frac{\varepsilon_0 vB}{2}, \sigma_2 = \frac{-\varepsilon_0 vB}{2}$

(3) $\sigma_1 = \sigma_2 = -\varepsilon_0 vB$

(4) $\sigma_1 = \frac{-\varepsilon_0 vB}{2}, \sigma_2 = \frac{\varepsilon_0 vB}{2}$

16. A fighter plane of length 20 m, wing span (distance from tip of one wing to the tip of the other wing) of 15 m and height 5 m is flying towards east over Delhi. Its speed is 240 ms^{-1}. The earth's magnetic field over Delhi is 5×10^{-5} T with the declination angle $\sim 0°$ and dip of θ such that $\sin\theta = \frac{2}{3}$. If the voltage developed is V_B between the lower and upper side of the plane and V_W between the tips of the wings then V_B and V_W are close to :

(1) V_B =45 mV; V_W =120 mV with right side of pilot at higher voltage

(2) V_B =45 mV; V_W =120 mV with left side of pilot at higher voltage

(3) V_B =40 mV; V_W =135 mV with right side of pilot at higher voltage

(4) V_B =40 mV; V_W =135 mV with lrft side of pilot at higher voltage

17. A conducting metal circular-wire-loop of radius r is placed perpendicular to a magnetic field which varies with time as

$B = B_0 e^{-t/\tau}$, where B_0 and τ are constants, at time t=0. If the resistance of the loop is R then the heat generated in the loop after a long time ($t \to \infty$) is :

(1) $\frac{\pi^2 r^4 B_0^4}{2\tau R}$

(2) $\frac{\pi^2 r^4 B_0^2}{2\tau R}$

(3) $\frac{\pi^2 r^4 B_0^4 R}{\tau}$

(4) $\frac{\pi^2 r^4 B_0^4}{\tau R}$

18. Consider an electromagnetic wave propagating in vacuum. Choose the correct statement :

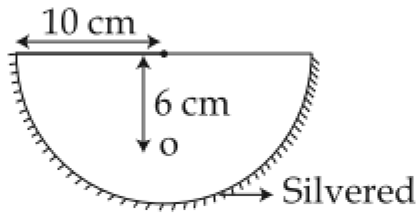
(1) For an electromagnetic wave propagating in +x direction the electric field is $\vec{E} = \frac{1}{\sqrt{2}} E_{yz}(x,t)(\hat{y} - \hat{z})$ and the magnetic field is $\vec{B} = \frac{1}{\sqrt{2}} B_{yz}(x,t)(\hat{y} + \hat{z})$

(2) For an electromagnetic wave propagating in +*x* direction the electric field is $\vec{E} = \frac{1}{\sqrt{2}} E_{yz}(y,z,t)(\hat{y}+\hat{z})$ and the magnetic field is $\vec{B} = \frac{1}{\sqrt{2}} B_{yz}(y,z,t)(\hat{y}+\hat{z})$

(3) For an electromagnetic wave propagating in +*y* direction the electric field is $\vec{E} = \frac{1}{\sqrt{2}} E_{yz}(x,t)\hat{y}$ and the magnetic field is $\vec{B} = \frac{1}{\sqrt{2}} B_{yz}(x,t)\hat{z}$

(4) For an electromagnetic wave propagating in +*y* direction the electric field is $\vec{E} = \frac{1}{\sqrt{2}} E_{yz}(x,t)\hat{z}$ and the magnetic field is $\vec{B} = \frac{1}{\sqrt{2}} B_{yz}(x,t)\hat{y}$

19. A hemispherical glass body of radius 10 cm and refractive index 1.5 is silvered on its curved surface. A small air bubble is 6 cm below the flat surface inside it along the axis. The position of the image of the air bubble made by the mirror is seen :



(1) 14 cm below flat surface

(2) 30 cm below flat surface

(3) 20 cm below flat surface

(4) 16 cm below flat surface

20. Two stars are 10 light years away from the earth. They are seen through a telescope of objective diameter 30 cm. The wavelength of light is 600 nm. To see the stars just resolved by the telescope, the minimum distance between them should be (1 light year = 9.46×10^{15} m) of the order of :

(1) 10^6 km

(2) 10^8 km

(3) 10^{11} km

(4) 10^{10} km

21. A photoelectric surface is illuminated successively by monochromatic light of wavelengths λ and $\frac{\lambda}{2}$. If the maximum

kinetic energy of the emitted photoelectrons in the second case is 3 times that in the first case, the work function of the surface is :

(1) $\frac{hc}{3\lambda}$

(2) $\frac{hc}{2\lambda}$

(3)

(4) $\frac{3hc}{\lambda}$

22. A neutron moving with a speed '*v*' makes a head on collision with a stationary hydrogen atom in ground state. The minimum kinetic energy of the neutron for which inelastic collision will take place is :

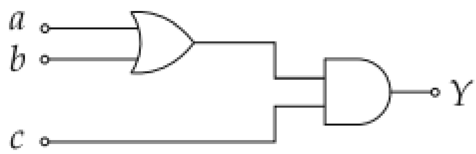
(1) 10.2 eV

(2) 16.8 eV

(3) 12.1 eV

(4) 20.4 eV

23. To get an output of 1 from the circuit shown in figure the input must be :



(1) $a = 0, b = 1, c = 0$

(2) $a = 1, b = 0, c = 0$

(3) $a = 1, b = 0, c = 1$

(4) $a = 0, b = 0, c = 1$

24. A modulated signal $C_m(t)$ has the form $C_m(t) = 30\sin 300\pi t + 10\ (\cos 200\pi t\ - \cos 400\pi t)$. The carrier frequency f_c, the modulating frequency (message frequency) f_ω, and the modulation index μ are respectively given by :

(1) $f_c = 200\text{ Hz};\ f_\omega = 50\text{ Hz};\ \mu = \frac{1}{2}$

(2) $f_c = 150\text{ Hz};\ f_\omega = 50\text{ Hz};\ \mu = \frac{2}{3}$

(3) $f_c = 150\text{ Hz};\ f_\omega = 30\text{ Hz};\ \mu = \frac{1}{3}$

(4) $f_c = 200\text{ Hz};\ f_\omega = 30\text{ Hz};\ \mu = \frac{1}{2}$

25. A particle of mass m is acted upon by a force F given by the empirical law $F = \frac{R}{t^2} v(t)$. If this law is to be tested experimentally by observing the motion starting from rest, the best way is to plot :

(1) $v(t)$ against t^2

(2) $\log v(t)$ against $\frac{1}{t^2}$

(3) $\log v(t)$ against t

(4) $\log v(t)$ against $\frac{1}{t}$

26. A thin 1 m long rod has a radius of 5 mm. A force of 50 πkN is applied at one end to determine its Young's modulus. Assume that the force is exactly known. If the least count in the measurement of all lengths is 0.01 mm, which of the following statements is false ?

(1) $\frac{\Delta Y}{Y}$ gets minimum contribution from the uncertainty in the length.

(2) The figure of merit is the largest for the length of the rod.

(3) The maximum value of Y that can be determined is 10^{14} N/m^2.

(4) $\frac{\Delta Y}{Y}$ gets its maximum contribution from the uncertainty in strain.

27. A galvanometer has a 50 division scale. Battery has no internal resistance. It is found that there is deflection of 40 divisions when R=2400 Ω. Deflection becomes 20 divisions when resistance taken from resistance box is 4900 Ω. Then we can conclude :

(1) Resistance of galvanometer is 200 Ω.

(2) Full scale deflection current is 2 mA.

(3) Current sensitivity of galvanometer is 20 μA/division.

(4) Resistance required on R.B. for a deflection of 10 divisions is 9800 Ω.

28. To determine refractive index of glass slab using a travelling microscope, minimum number of readings required are :

(1) Two

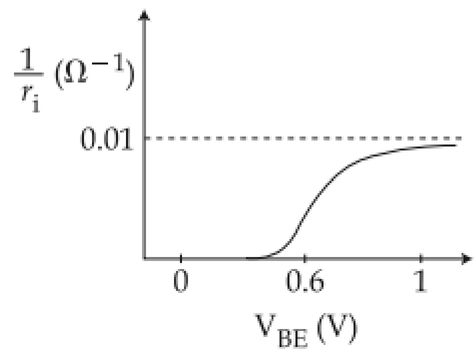
(2) Three

(3) Four

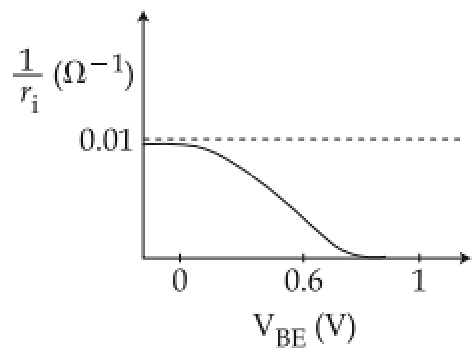
(4) Five

29. A realistic graph depicting the variation of the reciprocal of input resistance in an input characteristics measurement in a common-emitter transistor configuration is :

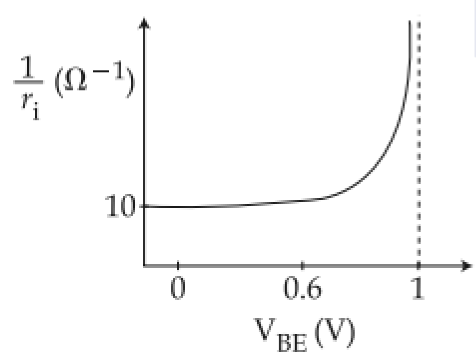
(1)

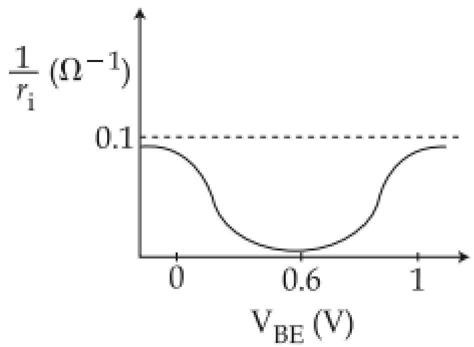


(2)



(3)





(4)

30. The ratio (R) of output resistance r_0, and the input resistance r_i in measurements of input and output characteristics of a transistor is typically in the range :

(1) $R \sim 10^2 - 10^3$

(2) $R \sim 1 - 10$

(3) $R \sim 0.1 - 0.01$

(4) $R \sim 0.1 - 1.0$

PART-2

1. The expression is given as,

$1.67\times10^{5}\ \text{J}$

Thus, $1.9\ \text{Hz}$ is a dimensionless quantity.

Therefore it can be concluded that,

$170\ \text{Hz}$ …… (1)

And,

$\rho(r)\propto\frac{1}{r}$ …… (2)

Check the first option.

(1) $\frac{32}{23}\ \mu\text{F}$

Given that,

$\Phi_1=\Phi_2=\Phi_3=\Phi_4$

Therefore, $400\ \Omega$ and $P_2>P_1>P_3$ have the same dimensions.

Check the second option.

(2) $7\ \Omega$ and $45°$

The quantities $\frac{2E_0}{c}\hat{j}\cos kz \cos \omega t$ and $27.5\ \text{cm}$ do not have the same dimensions; thus there is no meaning attached to it.

Check the third option.

(3) 9 mm

10^{20}

The quantities $\frac{h^2}{4\pi m^2 r^3}$ and $4\times10^{-2}\ \text{gm}$ have the same dimensions. Thus, this option stands meaningful.

Check the fourth option.

(4) 6.9 mA

This option is meaningful.

2. The centripetal acceleration of the particle is given by,

$$\lambda, P_{eff} = K\left(\frac{1}{\lambda}\right)^2$$

The centripetal acceleration of the particle is also given by,

$$\frac{20}{3}\Omega$$

Equate both the equations stated above.

$$0.1\,\text{cm}$$

Thus, tangential acceleration is calculated as,

$$P = a^{1/2}b^2c^3d^{-4}$$

The power delivered to the particle is given by,

$$\frac{\Delta P}{P} = \left[\left(\frac{1}{2}\frac{\Delta a}{a}\right) + \left(2\frac{\Delta b}{b}\right) + \left(3\frac{\Delta c}{c}\right) + \left(4\frac{\Delta d}{d}\right)\right] \times 100\,\%$$

Substitute the value of

$$\frac{\Delta P}{P} = \left[\left(\frac{1}{2}\times 2\right)+(2\times 1)+(3\times 3)+(4\times 5)\right]\%$$
$$= [1+2+9+20]\%$$
$$= 32\%$$

, and 32 % in above expression.

$$s = ut + \frac{1}{2}at^2$$

3. The expression to calculate the velocity to just complete one rotation at the top point is given by,

$$s = (0)t + \frac{1}{2}at^2$$
$$s = \frac{1}{2}at^2$$
$$t = \sqrt{\frac{2s}{a}}$$

For the drum, the rotational speed is given by,

$(d + 200)$

Substitute the given values of $t = \sqrt{\frac{2d}{2}}$ and $(d + 200)$, that is,

$$\sqrt{\frac{2d}{2}} = \sqrt{\frac{2(d+200)}{4}}$$

$t = \sqrt{\frac{2(d+200)}{4}}$ and $d = \frac{(d+200)}{2}$ in the above

$$d = 200 \text{ m}$$

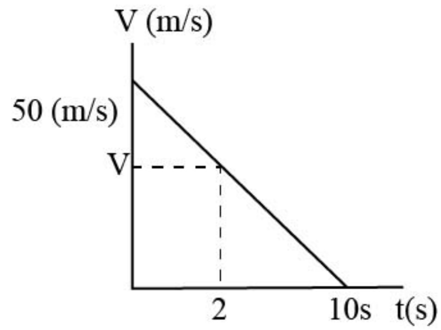
equation.

$$t = \sqrt{\frac{2(200 \text{ m})}{2}}$$
$$= 10\sqrt{2} \text{ s}$$

The maximum rotational speed of the drum in revolution per minute is calculated as,

$10\sqrt{2}$ s

4. The following figure shows the velocity-time graph for the body.



The acceleration of the body is given by,

M'

Substitute the values in the above expression.

υ'

The final velocity at any time

$$2M'\upsilon'\sin\theta = M\upsilon\cos45^\circ + M\upsilon\cos30^\circ$$

$$2M'\upsilon'\sin\theta = \frac{M\upsilon}{\sqrt{2}} + \frac{\sqrt{3}M\upsilon}{2}$$

$$2M'\upsilon'\sin\theta = M\upsilon\left(\frac{1}{\sqrt{2}} + \frac{\sqrt{3}}{2}\right)$$ is calculated as,

$$2M'\upsilon'\cos\theta = -M\upsilon\sin45^\circ + M\upsilon\sin30^\circ$$

$$2M'\upsilon'\cos\theta = -\frac{M\upsilon}{\sqrt{2}} + \frac{M\upsilon}{2}$$

$$2M'\upsilon'\cos\theta = M\upsilon\left(-\frac{1}{\sqrt{2}} + \frac{1}{2}\right)$$

$$\frac{2M'\upsilon'\sin\theta}{2M'\upsilon'\cos\theta} = \frac{M\upsilon\left(\frac{1}{\sqrt{2}} + \frac{\sqrt{3}}{2}\right)}{M\upsilon\left(-\frac{1}{\sqrt{2}} + \frac{1}{2}\right)}$$

The final velocity at $\tan\theta = \frac{\left(\frac{\sqrt{2}+\sqrt{3}}{2}\right)}{\left(\frac{1-\sqrt{2}}{2}\right)}$ is calculated

$$\tan\theta = \frac{\sqrt{3}+\sqrt{2}}{1-\sqrt{2}}$$

as,

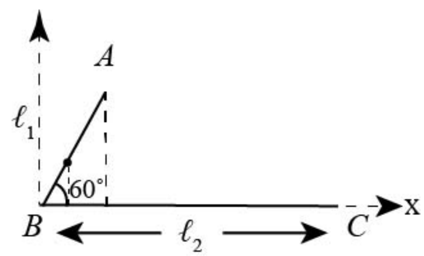
θ

Consider the work energy theorem.

The change in kinetic energy is calculated as,

$$\tan\theta = \frac{\sqrt{3}+\sqrt{2}}{1-\sqrt{2}}$$

5. The following figure shows the wire ABC.



The center of mass lies vertically below *A*.

Choose the axis in *x*-coordinate equal to ΔPQR .

The centre of mass along the *x*-axis is calculated as,

$$h = \sqrt{1^2 - \left(\frac{x}{2}\right)^2}$$

$$= \frac{1}{2}\sqrt{4 - x^2}$$

Further simplify the above equation.

$$v = \frac{dh}{dt} \qquad \text{..... (1)}$$

Use the determinant method to finds the roots of the quadratic equation.

$$\frac{dh}{dt}$$

Consider equation (1). Therefore, the possible value of

$$\frac{dh}{dt}=\frac{d}{dt}\left(\frac{1}{2}\sqrt{4-x^2}\right)$$

$$=\frac{1}{2}\frac{d}{dx}\left(\frac{1}{2}\sqrt{4-x^2}\right)\frac{dx}{dt}$$

are,

$$=\frac{1}{4}\left(\frac{1}{\sqrt{4-x^2}}\right)(-2x)\frac{dx}{dt}$$

$$=-\frac{x}{2\sqrt{4-x^2}}\frac{dx}{dt}$$

$$\frac{dh}{dt}=-\frac{1}{2\sqrt{\frac{4}{x^2}-1}}\frac{dx}{dt}$$

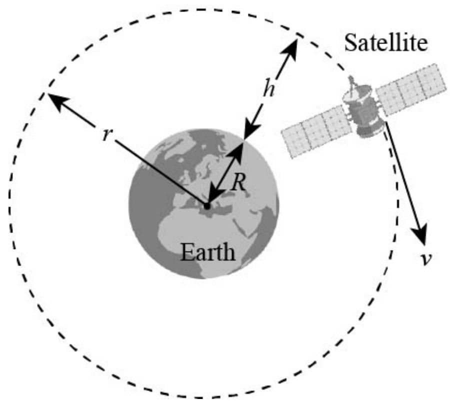
Rationalize the above relation,

$$\sqrt{\frac{4}{x^2}-1}$$

6. The orbital velocity of satellite is given by,

$$\sqrt{\frac{4}{x^2}-1}$$

The following figure shows the orbital path of the satellite.



Here, $\frac{dh}{dt}$ is the radius of the orbital path of the satellite from the centre of earth; that is, $T\cos\theta = mg$, and $T\sin\theta = \frac{mv^2}{r}$ is the orbital velocity.

The Newton's Law of Gravitation is given by,

$$\tan\theta = \frac{v^2}{rg}$$

$$\tan 45° = \frac{v^2}{(0.4\text{ m})(10\text{ ms}^{-2})}$$

Here, $v^2 = 4\text{ m}^2\text{s}^{-2}$ is the gravitational constant.

$$v = \sqrt{4\text{ m}^2\text{s}^{-2}}$$

$$v = 2\text{ ms}^{-1}$$

Thus, as per the law of gravitation, the gravitational pull on the astronaut is given by,

$2\ \text{ms}^{-1}$

7. The expression for stress is given by,

$$I_{disc} = \frac{MR^2}{2} \qquad \text{...... (1)}$$

The stress can also be expressed as,

$$I_{removed} = \frac{1}{2}\left(\frac{M}{16}\right)\left(\frac{R^2}{16}\right) + \left(\frac{M}{16}\right)\left(\frac{9R^2}{16}\right)$$

$$= \frac{MR^2 + 18MR^2}{512}$$

$$= \frac{19MR^2}{512}$$

...... (2)

Here, the strain is given by,

$$I_{remaining} = \frac{MR^2}{2} - \frac{19MR^2}{512}$$

$$= \frac{237MR^2}{512}$$

The change in volume is given by,

$$\frac{237MR^2}{512}$$

The original volume is given by,

$$\rho = \frac{m}{v} = \frac{k}{r}$$

Substitute the values in equation (2).

$$m = \frac{kv}{r}$$

The force required to push the cork into the bottle is calculated as,

$$g_{inside} = \frac{Gmr}{R^3}$$

$$= \left(\frac{Gr}{R^3}\right)\left(\frac{kv}{r}\right)$$

$$= \frac{Gkv}{R^3}$$

8. Heat required to freeze $\frac{Gkv}{R^3}$ water is calculated as,

$$g_{out} = \frac{Gm}{r^2}$$

This heat further acts as $F = Y\alpha_L A\Delta t$.

As per the Carnot's cycle,

$$F = \left(2\times10^{11}\ \text{Nm}^{-2}\right)\left(1.2\times10^{-5}\ \text{K}^{-1}\right)\left(40\times10^{-4}\ \text{m}^2\right)\left(10\right)$$
$$= 9.6\times10^4\ \text{N}$$
$$= 1\times10^5\ \text{N}$$

The work done is equal to the difference in the heat added to the system and heat rejected by the system.

$$Q = \frac{\pi r^4}{8\eta}\frac{\Delta P}{L}$$

Thus, the energy consumed by the freezer is $\frac{P_1 r_1^4}{l_1} = \frac{P_2 r_2^4}{l_2}$, $\frac{P_1 r_1^4}{l_1} = \frac{4P_1 r_2^4}{\frac{I_1}{4}}$.

$$r_2^4 = \frac{r_1^4}{16}$$

$$r_2 = \frac{r_1}{2}$$

9. The expression as per the concept of thermodynamics for an Ideal gas that is at constant temperature is given by,

$$u_{\text{initial}} = \frac{5}{2}\text{NRT}$$

Thus, it can be concluded that,

$$\begin{aligned} u_{\text{final}} &= \frac{3}{2}\left(2\text{nRT}\right)+\frac{5}{2}\left(\text{N-n}\right)\text{RT} \\ &= \frac{1}{2}\text{nRT}+\frac{5}{2}\text{NRT} \end{aligned}$$

Hence, the pressure versus density graph varies linearly, that is the pressure increases with an increase in density.

10. As washer does not stay in contact with the piston any longer.

Hence,

$$\begin{aligned} U_{\text{total}} &= \frac{1}{2}\text{nRT}+\frac{5}{2}\text{NRT}-\frac{5}{2}\text{NRT} \\ &= \frac{1}{2}\text{nRT} \end{aligned}.$$

The frequency is given by,

$$a = a_0 e^{\frac{-bt}{m}}$$

The angular velocity is given by,

$$E \propto a^2$$

$$a \propto E$$

Consider the above two relations to determine the frequency.

The frequency is calculated as,

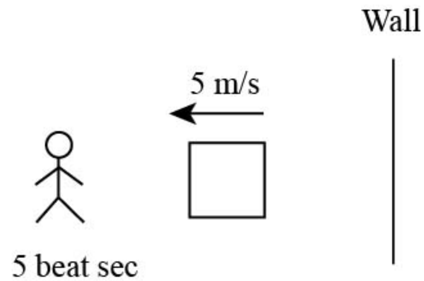
$$a = \frac{a_0}{\sqrt{2}} = \frac{bt}{m}$$

$$\frac{a_0}{\sqrt{2}} = \frac{bt}{m}$$

$$= \frac{10^{-2}t}{0.1}$$

$$= \frac{t}{10}$$

11. The following figure is a pictorial representation of the given case.



Consider the Doppler Effect,

$$\frac{a_0}{\sqrt{2}} = a_0 e^{-\frac{t}{10}}$$

$$\frac{1}{\sqrt{2}} = e^{-\frac{t}{10}} \qquad \text{...... (1)}$$

$$\ln\sqrt{2} = \frac{t}{10}$$

$$t = 3.5 \text{ sec}$$

Here, v is the speed of the sound in air and $v = \frac{\omega}{k}$ is the speed of the source moving.

The apparent frequency from the wall is given by,

$$v = \frac{200\pi}{\left(\frac{5\pi}{4}\right)} \qquad \text{...... (2)}$$

$$= 160 \text{ m/s}$$

The expression for beat frequency is given by,

$$\Phi_1 = \Phi_2 = \Phi_3 = \Phi_4 \qquad \text{...... (3)}$$

Form the equation. (1), (2) and (3),

$$C = \frac{\varepsilon_0 A}{3}$$

12. The expression for the electric field is given by:

$$C = \frac{\left(\frac{k\varepsilon_0 A}{3}\right)\left(\frac{\varepsilon_0 A}{2.4}\right)}{\frac{k\varepsilon_0 A}{3} + \frac{\varepsilon_0 A}{2.4}}$$

$$\frac{\varepsilon_0 A}{3} = \frac{\left(\frac{k\varepsilon_0 A}{3}\right)\left(\frac{\varepsilon_0 A}{2.4}\right)}{\frac{k\varepsilon_0 A}{3} + \frac{\varepsilon_0 A}{2.4}}$$

The electric field, $3k = 2.4k + 3$ is constant. This

$k = 5$

implies that the change in ratio of $\sigma_1 = \varepsilon_0 \upsilon B$, $\sigma_2 = -\varepsilon_0 \upsilon B$ and $\frac{(A - C)}{D}$ remains the same.

Thus,

$MnR^2 t$

Substitute the values in the above relation.

–4500 J

Further simplify the integral function.

1.37

13. The expression for the capacitors grouped in series is given by,

$$F_G = \frac{GMm}{(R+h)^2}$$

The expression for the capacitors grouped in parallel is given by,

$(4\pi\mu Bb)\Delta n$

Apply the circuit reduction method.

Capacitors 1.67×10^5 J and 1.9 Hz are parallel to each other.

So, their equivalent capacitance is calculated as,

170 Hz

Similarly, the capacitors $\rho(r)\propto\frac{1}{r}$ and $\frac{32}{23}\,\mu F$ are in series. Thus,

their equivalent capacitance is,

$\sigma_1 = \varepsilon_0 \upsilon B, \sigma_2 = -\varepsilon_0 \upsilon B$

The capacitors having the capacitance of $400\,\Omega$ and $P_2 > P_1 > P_3$ are in series. Thus, their equivalent capacitance is,

$7\,\Omega$ and $45°$

The capacitors having the capacitance of $\frac{2E_0}{c}\hat{j}\cos kz \cos \omega t$ and 27.5 cm are in parallel. Thus, their equivalent capacitance is,

9 mm

In the reduced circuit, the 10^{20} is in series with $\frac{h^2}{4\pi m^2 r^3}$. Thus, their equivalent capacitance is,

$4\times10^{-2}\text{ gm}$

Finally the net capacitance of the circuit is calculated as,

6.9 mA

Hence, the required circuit equivalent capacitance is calculated as,

$\lambda, P_{eff} = K\left(\frac{1}{\lambda}\right)^2$

14. The power dissipated is given by,

$\frac{20}{3}\Omega$

Substitute the given values in the above equation.

$0.1\,\text{cm}$

Here, $P = a^{1/2}b^2c^3d^{-4}$ is the temperature at

$$\frac{\Delta P}{P} = \left[\left(\frac{1}{2}\frac{\Delta a}{a}\right) + \left(2\frac{\Delta b}{b}\right) + \left(3\frac{\Delta c}{c}\right) + \left(4\frac{\Delta d}{d}\right)\right] \times 100\,\%$$ and

$$\frac{\Delta P}{P} = \left[\left(\frac{1}{2}\times 2\right) + (2\times 1) + (3\times 3) + (4\times 5)\right]\%$$

$= [1+2+9+20]\,\%$ is the temperature at

$= 32\,\%$

$32\,\%$.

Thus, the temperature difference at time $s = ut + \frac{1}{2}at^2$ is

calculated as,

$$s = (0)t + \frac{1}{2}at^2$$

$$s = \frac{1}{2}at^2$$

$$t = \sqrt{\frac{2s}{a}}$$

The net work done to raise the temperature is given by,

$$(d + 200)$$

Substitute the values in the above equation.

$$t = \sqrt{\frac{2d}{2}} \qquad \ldots\ldots. (1)$$

Determine the value of $(d + 200)$ from the following relation.

$$t = \sqrt{\frac{2(d + 200)}{4}}$$

Substitute the values in the above relation.

$$\sqrt{\frac{2d}{2}} = \sqrt{\frac{2(d+200)}{4}}$$

$$d = \frac{(d+200)}{2}$$

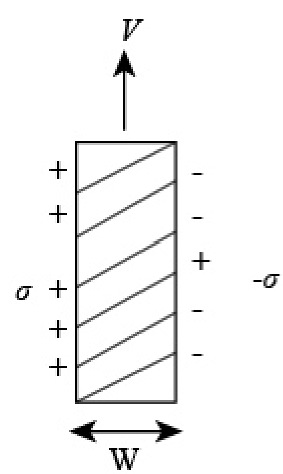
$$d = 200 \text{ m}$$

Substitute the value of $t = \sqrt{\frac{2(200\text{ m})}{2}}$ in equation (1).

$$= 10\sqrt{2} \text{ s}$$

$10\sqrt{2}$ s

15. The following figure shows the charge distribution of the sheet.



The force on a charged particle that is placed in a magnetic field is given by, M′

Here, υ′ is the velocity of the particles and

$$2M'\upsilon'\sin\theta = M\upsilon\cos45° + M\upsilon\cos30°$$

$$2M'\upsilon'\sin\theta = \frac{M\upsilon}{\sqrt{2}} + \frac{\sqrt{3}M\upsilon}{2}$$

$$2M'\upsilon'\sin\theta = M\upsilon\left(\frac{1}{\sqrt{2}} + \frac{\sqrt{3}}{2}\right)$$ is the magnetic field.

For the case when the magnetic fields are mutually perpendicular to each other,

$$2M'\upsilon'\cos\theta = -M\upsilon\sin45° + M\upsilon\sin30°$$

$$2M'\upsilon'\cos\theta = -\frac{M\upsilon}{\sqrt{2}} + \frac{M\upsilon}{2}$$

$$2M'\upsilon'\cos\theta = M\upsilon\left(-\frac{1}{\sqrt{2}} + \frac{1}{2}\right)$$

Magnetic force on electron I metal sheet is given by,

$$\frac{2M'\upsilon'\sin\theta}{2M'\upsilon'\cos\theta} = \frac{M\upsilon\left(\frac{1}{\sqrt{2}} + \frac{\sqrt{3}}{2}\right)}{M\upsilon\left(-\frac{1}{\sqrt{2}} + \frac{1}{2}\right)}$$

$$\tan\theta = \frac{\left(\frac{\sqrt{2}+\sqrt{3}}{2}\right)}{\left(\frac{1-\sqrt{2}}{2}\right)}$$

$$\tan\theta = \frac{\sqrt{3}+\sqrt{2}}{1-\sqrt{2}}$$

At the equilibrium condition,

θ

Thus,

$$\tan\theta = \frac{\sqrt{3}+\sqrt{2}}{1-\sqrt{2}} \qquad \ldots\ldots (1)$$

The electric field is given by,

ΔPQR

Thus,

$$h = \sqrt{1^2 - \left(\frac{x}{2}\right)^2}$$

$$= \frac{1}{2}\sqrt{4 - x^2}$$

Thus, the value of $v = \frac{dh}{dt}$ is given by,

$$\frac{dh}{dt}$$

Substitute the above value in the equation (1).

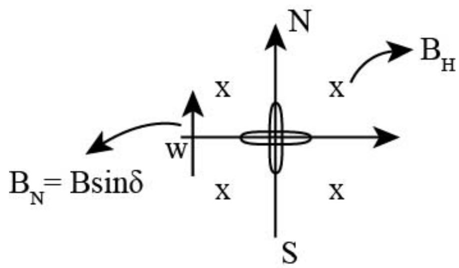
$$\frac{dh}{dt} = \frac{d}{dt}\left(\frac{1}{2}\sqrt{4 - x^2}\right)$$

$$= \frac{1}{2}\frac{d}{dx}\left(\frac{1}{2}\sqrt{4 - x^2}\right)\frac{dx}{dt}$$

$$= \frac{1}{4}\left(\frac{1}{\sqrt{4 - x^2}}\right)(-2x)\frac{dx}{dt}$$

$$= -\frac{x}{2\sqrt{4 - x^2}}\frac{dx}{dt}$$

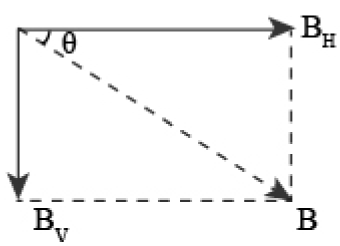
16. The following figure represents the given case.



The expression for the magnetic field is given by,

$$\frac{dh}{dt} = -\frac{1}{2\sqrt{\frac{4}{x^2}-1}}\frac{dx}{dt}$$

Resolve the magnetic field.



Potential difference across wings is given by,

$$\sqrt{\frac{4}{x^2}-1}$$

Substitute the value in the above equation.

$$\sqrt{\frac{4}{x^2}-1}$$

The left side is at high voltage. Therefore, the potential drop between top and bottom of the plane is given by,

$$\frac{dh}{dt}$$

Substitute the values in the above equation.

$$T\cos\theta = mg$$

Therefore, as per the right hand thumb rule, the charge will move to left side of the pilot.

17. The expression for the flow of current into the loop of wire is given by,

$$T\sin\theta = \frac{mv^2}{r}$$

Substitute the values in the above expression.

$$\tan\theta = \frac{v^2}{rg}$$

The heat generated during the phenomenon is calculated as,

$$\tan 45° = \frac{v^2}{(0.4\ \text{m})(10\ \text{ms}^{-2})}$$

$$v^2 = 4\ \text{m}^2\text{s}^{-2}$$

$$v = \sqrt{4\ \text{m}^2\text{s}^{-2}}$$

$$v = 2\ \text{ms}^{-1}$$

Therefore, the heat generated in the loop after a long time, that is at $2\ \text{ms}^{-1}$ is $I_{disc} = \frac{MR^2}{2}$.

18. Considering the case of electromagnetic waves, the electric field and magnetic field have their direction perpendicular to the direction of the propagation, which corresponds to current by right hand rule.

Therefore, both options 1 and 2 are incorrect.

Further, the direction of propagation is obtained from the cross product of the electric field and magnetic field; that is,

$$I_{\text{removed}} = \frac{1}{2}\left(\frac{M}{16}\right)\left(\frac{R^2}{16}\right) + \left(\frac{M}{16}\right)\left(\frac{9R^2}{16}\right)$$

$$= \frac{MR^2 + 18MR^2}{512} \quad .$$

$$= \frac{19MR^2}{512}$$

Thus, from the above two remaining options,

$$I_{\text{remaining}} = \frac{MR^2}{2} - \frac{19MR^2}{512}$$

$$= \frac{237MR^2}{512}$$

Hence, if the wave is propagating along the $\frac{237MR^2}{512}$ direction

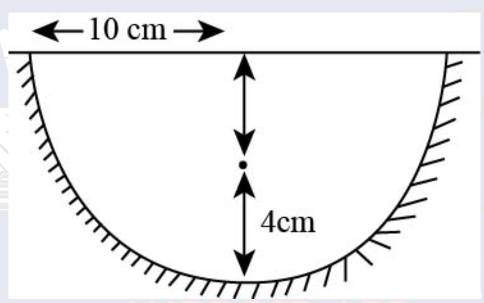
then, $\rho = \frac{m}{v} = \frac{k}{r}$ and $m = \frac{kv}{r}$ must be a function of

$$g_{inside} = \frac{Gmr}{R^3}$$

$$= \left(\frac{Gr}{R^3}\right)\left(\frac{kv}{r}\right)$$, and must be along the $\frac{Gkv}{R^3}$ plane.

$$= \frac{Gkv}{R^3}$$

19. The following figure shows the hemispherical glass body.



The expression for the position of the image formed from the mirror is given by,

$$g_{out} = \frac{Gm}{r^2}$$

Substitute the values with sign convention in the above equation.

$$F = Y\alpha_L A\Delta t$$

The magnification of image is calculated as,

$$F = \left(2\times10^{11}\ \text{Nm}^{-2}\right)\left(1.2\times10^{-5}\ \text{K}^{-1}\right)\left(40\times10^{-4}\ \text{m}^{2}\right)(10)$$

$$= 9.6\times10^{4}\ \text{N}$$

$$= 1\times10^{5}\ \text{N}$$

Since the value of magnification comes out to be negative, the image is formed below the plane surface.

20. The expression for the angle is given by,

$$Q = \frac{\pi r^4}{8\eta}\frac{\Delta P}{L}$$

Simplify the above expression.

$$\frac{P_1 r_1^4}{l_1} = \frac{P_2 r_2^4}{l_2}$$

$$\frac{P_1 r_1^4}{l_1} = \frac{4P_1 r_2^4}{\frac{I_1}{4}}$$

$$r_2^4 = \frac{r_1^4}{16}$$

$$r_2 = \frac{r_1}{2}$$

Therefore, the minimum distance between the stars and telescope is of the order of $u_{initial} = \frac{5}{2} NRT$.

21. The expression for the energy of the first monochromatoic wave is given by,

$$u_{final} = \frac{3}{2}(2nRT) + \frac{5}{2}(N\text{-}n)RT$$
$$= \frac{1}{2} nRT + \frac{5}{2} NRT$$

The expression for the energy of the second monochromatoic wave is given by,

$$U_{total} = \frac{1}{2}nRT + \frac{5}{2}NRT - \frac{5}{2}NRT$$
$$= \frac{1}{2}nRT$$

Therefore, the kinetic energy of the first monochromatoic wave is calculated as,

$$a = a_0 e^{\frac{-bt}{m}}$$

The kinetic energy of the second monochromatoic wave is calculated as,

$$E \propto a^2$$
$$a \propto E$$

The given relation is,

$$a = \frac{a_0}{\sqrt{2}} = \frac{bt}{m}$$

$$\frac{a_0}{\sqrt{2}} = \frac{bt}{m}$$
$$= \frac{10^{-2}t}{0.1}$$
$$= \frac{t}{10}$$

Substitute the values in the above equation.

$$\frac{a_0}{\sqrt{2}} = a_0 e^{-\frac{t}{10}}$$

$$\frac{1}{\sqrt{2}} = e^{-\frac{t}{10}}$$

$$\ln\sqrt{2} = \frac{t}{10}$$

$$t = 3.5 \text{ sec}$$

22. The a neutron and a hydrogen atom collides, then the collision will be considered inelastic if a potion of the kinetic energy is utilized to excite an atom.

If $v = \frac{\omega}{k}$ is the speed with which the neutron moves after collision, then the hydrogen atom will travel with a velocity of

$$v = \frac{200\pi}{\left(\frac{5\pi}{4}\right)}$$ .with mass $\Phi_1 = \Phi_2 = \Phi_3 = \Phi_4$.

$$= 160 \text{ m/s}$$

The loss in kinetic energy is calculated as,

$$C = \frac{\varepsilon_0 A}{3}$$

This reduced kinetic energy is utilized in jumping from the 1st orbit to the 2nd orbit.

Thus,

$$C = \frac{\left(\frac{k\varepsilon_0 A}{3}\right)\left(\frac{\varepsilon_0 A}{2.4}\right)}{\frac{k\varepsilon_0 A}{3} + \frac{\varepsilon_0 A}{2.4}}$$

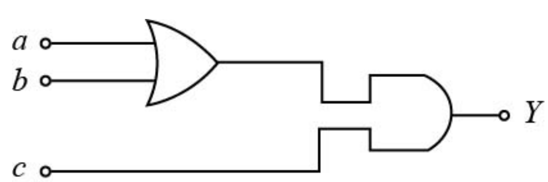
Substitute the value in the above expression.

$$\frac{\varepsilon_0 A}{3} = \frac{\left(\frac{k\varepsilon_0 A}{3}\right)\left(\frac{\varepsilon_0 A}{2.4}\right)}{\frac{k\varepsilon_0 A}{3} + \frac{\varepsilon_0 A}{2.4}}$$

$$3k = 2.4k + 3$$

$$k = 5$$

23. The following figure shows the circuit.



In case the required output has to be $V_B = 45\ \text{mV}$, then the following possible equation should be made.

$V_W = 120\ \text{mV}$

Consider the above equation. In order to get an output of $V_W = 120\ \text{mV}$, substitute,

$$\frac{(A-C)}{D}$$

But it is necessary to put MnR^2t.

Hence, the correct option is (3).

24. The given signal is of the form,

$-4500\ J$

Compare the given signal with the standard signal.

1.37

Also,

$$F_G = \frac{GMm}{(R+h)^2}$$

The expression for the angular frequency of the carrier is given by,

$$(4\pi\mu Bb)\Delta n$$

Hence, the correct option is (2)

25. The force acting on the particle is given by,

$$1.67\times10^5\ J$$

Therefore,

1.9 Hz

Integrate both sides of the above expression.

170 Hz

Therefore, it can be concluded that,

$$\rho(r)\propto\frac{1}{r}$$

So, graph should be plotted between $\frac{32}{23}\,\mu F$ against

$\sigma_1 = \varepsilon_0 \upsilon B, \sigma_2 = -\varepsilon_0 \upsilon B$.

26. The Young's modulus is given by,

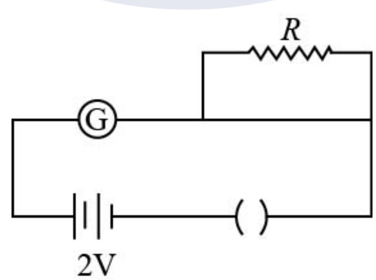
$V_B = 45\text{ mV}$

Substitute the given values in the above expression.

$V_W = 120\text{ mV}$

Therefore, the maximum value of $P_2 > P_1 > P_3$ that can be determined is $7\,\Omega$ and $45°$.

27. The following figure shows the circuit arrangement.



The current through the galvanometer if the deflection is of

$\frac{2E_0}{c}\hat{j}\cos kz \cos \omega t$ is calculated as,

27.5 cm ...... (1)

The current through the galvanometer if the resistance is taken from the resistance box is calculated as,

9 mm ...... (2)

Simplify equation (2).

10^{20}

Consider equation (1).

$$\frac{h^2}{4\pi m^2 r^3}$$

The full scale deflection of current through galvanometer is calculated as,

4×10^{-2} gm

For 10 divisions the value of 6.9 mA is calculated as,

$$\lambda, P_{eff} = K\left(\frac{1}{\lambda}\right)^2$$

So, only option (3) is correct.

28. Determining the refractive index of a glass slab with the help of a travelling microscope requires the readings

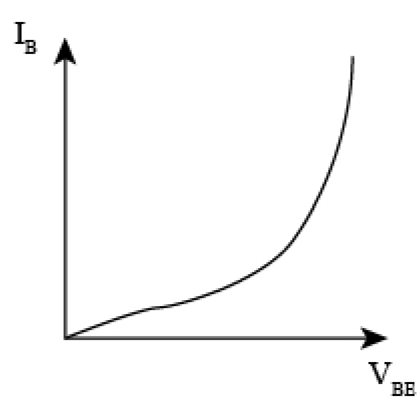
(1). without glass slab

(2). with glass slab

(3). with saw dust

Hence, the correct option is (2).

29. The following figure shows the input characteristics graph for the common emitter configuration,



Here,

$$\frac{20}{3}\,\Omega$$

Hence, the correct option is (1).

30. The ratio $0.1\,\text{cm}$ is given by,

$$P = a^{1/2} b^2 c^3 d^{-4}$$

Typically, the value of is approximately

$$\frac{\Delta P}{P} = \left[\left(\frac{1}{2}\frac{\Delta a}{a}\right) + \left(2\frac{\Delta b}{b}\right) + \left(3\frac{\Delta c}{c}\right) + \left(4\frac{\Delta d}{d}\right)\right] \times 100\,\%.$$

$$\frac{\Delta P}{P} = \left[\left(\frac{1}{2}\times 2\right) + (2\times 1) + (3\times 3) + (4\times 5)\right]\%$$

Therefore, $= [1+2+9+20]\,\%$ usually

$= 32\,\%$

adopt a value of the order of 100 to 1000 or $32\,\%$.