

PHYSICS

1. Ratio of acceleration due to gravity on the surface of planet 1 and planet 2 is  $x$  while the ratio of radii of respective planets is  $y$ . The ratio of respective escape velocity on the surface of planet 1 and planet 2 is equal to

- A.  $\sqrt{\frac{x}{y}}$   
B.  $\frac{x}{y}$   
C.  $\sqrt{xy}$   
D.  $xy$

Answer (C)

Solution:

Escape velocity can be given as:

$$v_e = \sqrt{\frac{2GM}{R} \times \frac{R}{R}} = \sqrt{2gR}$$

$$\text{So, } \frac{v_1}{v_2} = \sqrt{\frac{g_1}{g_2} \times \frac{R_1}{R_2}} = \sqrt{xy}$$

2. In a hydrogen atom, an electron makes a transition from 3<sup>rd</sup> excited state to ground state. Find the energy of the photon emitted.

- A. 10.8 eV  
B. 13.6 eV  
C. 12.75 eV  
D. 8.6 eV

Answer (C)

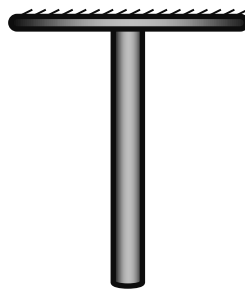
Solution:

$$\begin{aligned} \Delta E &= 13.6(1)^2 \left[ 1 - \frac{1}{4^2} \right] \text{ eV} \\ &= 13.6 \times \frac{15}{16} = 12.75 \text{ eV} \end{aligned}$$

3. A uniform rod of mass 10 kg and length 6 m is hanged from the ceiling as shown. Given area of cross-section of rod 3 mm<sup>2</sup> and Young's modulus is  $2 \times 10^{11} \frac{N}{m^2}$ . Find extension in the rod's length. [use  $g = 10 \text{ m/s}^2$ ]

- A. 1 mm  
B. 0.5 mm

- C. 0.25 mm
- D. 1.2 mm



**Answer (B)**

**Solution:**

Young's modulus,  $Y = 2 \times 10^{11} \frac{N}{m^2}$ .

Area =  $3 \text{ mm}^2$

Mass of the rod =  $10 \text{ kg}$

We know that:

$$\Delta L = \left( \frac{mgL}{2AY} \right) = \frac{10 \times 10 \times 6}{2 \times 3 \times 10^{-6} \times 2 \times 10^{11}} = \frac{1}{2} \times 10^{-3} \text{ m} = 0.5 \text{ mm}$$

4. For a heat engine based on Carnot cycle source is at temperature  $600 \text{ K}$ . Now if source temperature is *doubled* then efficiency also gets doubled while keeping the sink temperature same at  $x \text{ kelvin}$ . Value of  $x$  is equal to

- A. 400 K
- B. 600 K
- C. 200 K
- D. 300 K

**Answer (A)**

**Solution:**

Let the initial efficiency is  $x$  and sink temperature is  $T$  thus.

$$x = 1 - \frac{T}{600}$$

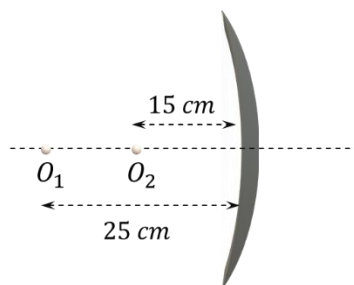
$$2x = 1 - \frac{T}{1200}$$

$$\frac{1}{2} = \frac{1 - \frac{T}{600}}{1 - \frac{T}{1200}} \Rightarrow \frac{T}{800} = \frac{1}{2}$$

$$T = 400 \text{ K}$$

5. Two point objects  $O_1$  and  $O_2$  are placed on principle axis of concave mirror of radius of curvature  $40 \text{ cm}$ . Find the distance between the two images.

- A. 160 cm
- B. 40 cm
- C. 100 cm
- D. 80 cm



**Answer (A)**

**Solution:**

For  $O_1$ :

$$u = -25 \text{ cm}$$

$$f = -20 \text{ cm}$$

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

$$\frac{1}{v_1} = \frac{1}{f} - \frac{1}{u} = -\frac{1}{20} + \frac{1}{25} = -\frac{1}{100} \Rightarrow v_1 = -100 \text{ cm}$$

For  $O_2$ :

$$u = -15 \text{ cm}$$

$$f = -20 \text{ cm}$$

$$\frac{1}{v_2} = -\frac{1}{20} + \frac{1}{15} = \frac{1}{60} \Rightarrow v_2 = +60$$

$$|v_1 - v_2| = [60 - (-100)] = 160 \text{ cm}$$

6. A train (moving with initial speed = 20 m/s) applies brakes to stop at the incoming station which is 500 m ahead. If brakes are applied after moving 250 m, then how much beyond the station train would stop?

- A. 125 m  
B. 500 m  
C. 250 m  
D. 400 m

**Answer (C)**

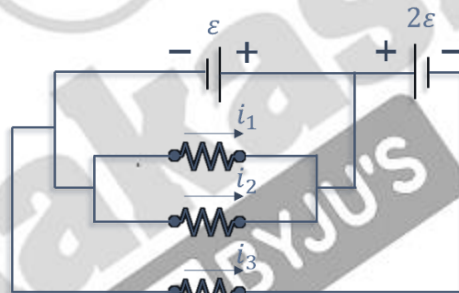
**Solution:**

The train needs 500 m to stop.

So, it will move beyond the station by 500 m – 250 m = 250 m

7. Consider the following circuit. All resistors have resistance  $10 \Omega$  each. Find  $\left| \frac{i_1 + i_2}{i_3} \right|$

- A. 2  
B. 1  
C. 3  
D. 1/3



**Answer (A)**

**Solution:**

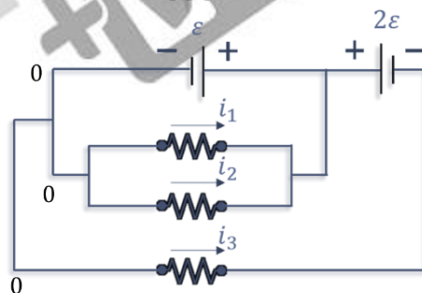
Magnitudes of current:

$$I_1 = -\varepsilon/R$$

$$I_2 = -\varepsilon/R$$

$$I_3 = \varepsilon/R$$

$$\left| \frac{I_1 + I_2}{I_3} \right| = \frac{2\varepsilon/R}{\varepsilon/R} = 2$$



8. Assertion (A): For making a voltmeter, we prefer a voltmeter of resistance of 4000  $\Omega$  over a voltmeter of resistance 1000  $\Omega$ .

Reason (R): Voltmeter should be of higher resistance such that it draws less current from the circuit.

- A. A and R both are true. R is correct explanation of A.  
B. A and R both are true. R is not the correct explanation of A.  
C. A is true but R is false.  
D. A is false but R is true.

**Answer (A)**

**Solution:**

The reason is correctly explaining the statement as, if more current is drawn the net resistance of circuit will change and we cannot get correct value of potential. To avoid this, we choose higher resistance.

9. According to the shown  $P - T$  graph of three processes, temperature at point  $O$  is equal to

- A.  $0^\circ C$
- B.  $-373^\circ C$
- C.  $100^\circ C$
- D.  $-273^\circ C$

**Answer (D)****Solution:**

All the gases will cease to exist at  $-273^\circ C$ , therefore the pressure will be zero so the temperature of point  $O$  is  $-273^\circ C$

10. A wire of length  $l$ , cross-sectional area  $A$  is pulled as shown.  $Y$  is the Young's modulus of wire. Find the elongation in wire if:  $F = 100\text{ N}$ ,  $A = 10\text{ cm}^2$ ,  $l = 1\text{ m}$ ,  $Y = 5 \times 10^{10}\text{ N/m}^2$

- A.  $10^{-6}\text{ m}$
- B.  $10^{-5}\text{ m}$
- C.  $2 \times 10^{-6}\text{ m}$
- D.  $2 \times 10^{-5}\text{ m}$

**Answer (C)****Solution:**

$$\Delta l = \frac{Fl}{AY} = 2 \times 10^{-6}$$

11. In a YDSE Setup, if a mica sheet of thickness ' $t$ ' and refractive index  $\mu$  is inserted in front of one of the slits. Find the number of fringes by which the central fringe gets shifted.  
[Given:  $\lambda$ ,  $D$  and  $d$  are wavelength of light, distance between slits and screen and slit separation respectively]

- A.  $\frac{\mu t}{\lambda}$
- B.  $\frac{(\mu-1)t}{\lambda}$
- C.  $\frac{(\mu+1)t}{\lambda}$
- D.  $\frac{(2\mu-1)t}{\lambda}$

**Answer (B)****Solution:**

$$\text{Path difference due to Mica sheet} = (\mu - 1)t$$

$$\text{Number of fringes shift} = \frac{(\mu-1)t \times D/d}{(\lambda D/d)} = (\mu - 1)t/\lambda$$

12. For a photoelectric setup, threshold frequency is  $f_0$ . For incident frequency of  $2f_0$ , stopping potential is  $V_1$  for incident frequency of  $5f_0$ , stopping potential is  $V_2$ . Find  $\frac{V_1}{V_2}$ .

- A.  $1/5$
- B.  $1/2$
- C.  $1/3$
- D.  $1/4$

**Answer (D)**

**Solution:**

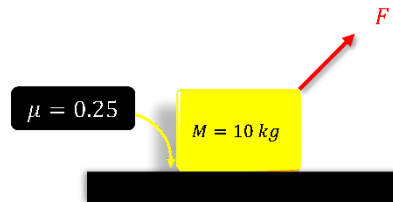
$$eV_1 = h(2f_0) - hf_0 = hf_0$$

$$eV_2 = h(5f_0) - hf_0 = 4hf_0$$

$$\frac{V_1}{V_2} = \frac{f_0}{4f_0} = \frac{1}{4}$$

13. A block is acted upon by a force  $F$  as shown. If  $M = 10 \text{ kg}$  and coefficient of friction is 0.25, find minimum  $F$  so that block slides.

- A.  $\frac{200}{4\sqrt{3}+1} \text{ N}$
- B.  $\frac{200}{4\sqrt{3}-1} \text{ N}$
- C.  $\frac{100}{4\sqrt{3}+1} \text{ N}$
- D.  $50 \text{ N}$



**Answer (A)**

**Solution:**

$$F \sin 30^\circ + N = Mg$$

$$F \cos 30^\circ = \mu N$$

$$\Rightarrow F = \frac{200}{1 + 4\sqrt{3}} \text{ N}$$

14. If universal gravitational constant ( $G$ ), Planck's constant ( $h$ ) and speed of light ( $c$ ) are taken as fundamental quantities then dimension of mass is equal to

- A.  $\sqrt{\frac{Gh}{c}}$
- B.  $\sqrt{\frac{G}{hc}}$
- C.  $\sqrt{\frac{h}{Gc}}$
- D.  $\sqrt{\frac{hc}{G}}$

**Answer (D)**

**Solution:**

$$[m] = [G]^x [h]^y [c]^z$$

$$[M] = [M^{-1}L^3T^{-2}]^x [ML^2T^{-1}]^y [LT^{-1}]^z$$

$$\text{So, } y - x = 1 \dots \dots \dots (1)$$

$$3x + 2y + z = 0 \dots \dots \dots (2)$$

$$-2x - y - z = 0 \dots \dots \dots (3)$$

On solving (1), (2) and (3)

$$x = -\frac{1}{2}, y = \frac{1}{2}, z = \frac{1}{2}$$

$$m = \sqrt{\frac{hc}{G}}$$

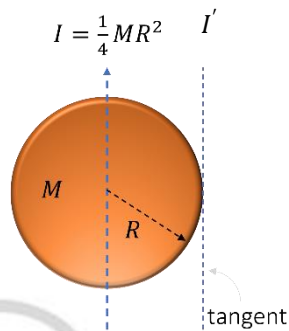
15. For uniform disc, moment of inertia about diameter is  $\frac{MR^2}{4}$ , where  $M$  is mass and  $R$  is radius of disc. Find the moment of inertia about tangent parallel to diameter.

- A.  $\frac{3}{4}MR^2$
- B.  $\frac{5}{4}MR^2$
- C.  $\frac{3}{2}MR^2$
- D.  $\frac{5}{2}MR^2$

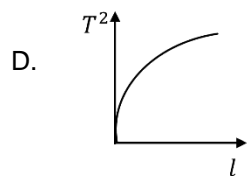
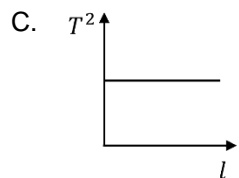
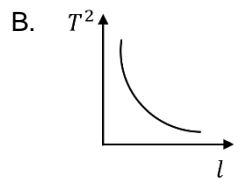
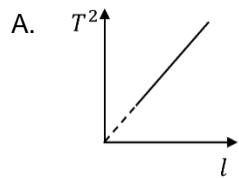
**Answer (B)**

**Solution:**

$$I' = \frac{1}{4}MR^2 + MR^2 = \frac{5}{4}MR^2$$



16. Which of the following graphs best represents the relation between square of time period and length of a simple pendulum?



**Answer (A)**

**Solution:**

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

$$T^2 = \frac{4\pi^2}{g} l$$

Thus, graph between  $T^2$  and  $l$  is a straight line passing through origin.

17. A uniform wire of resistance  $R$  is folded into a regular polygon of  $n$  sides. Find the equivalent resistance of this system between any two adjacent points.

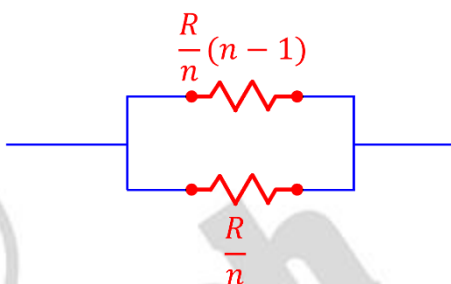
- A.  $\frac{n-1}{n} R$
- B.  $\frac{n-1}{n^2} R$
- C.  $\frac{n-1}{n^3} R$
- D.  $\frac{n+1}{n^2} R$

**Answer (B)**

**Solution:**

$$R_{eq} = \frac{\frac{R}{n}(n-1) \times \frac{R}{n}}{\frac{R}{n}(n-1) + \frac{R}{n}}$$

$$= \frac{(n-1) \frac{R}{n}}{n} = \frac{n-1}{n^2} R$$



18. Which of the following is correct for *zener* diode.

- 1) It acts as *voltage* regulator.
- 2) It is used in *forward bias*.
- 3) It is used in *reverse bias*.
- 4) It is used as switch in series.

- A. (1) and (4)
- B. (2) and (3)
- C. (1) and (3)
- D. (2) and (4)

**Answer (C)**

**Solution:**

Zener diode acts as voltage regulator. It is used in reverse bias.

19. Choose the correct statement regarding a ground-to-ground projectile:

- A. Kinetic energy is zero at highest point.
- B. Potential energy is highest at highest point.
- C. Horizontal component of velocity increases.
- D. Vertical component of velocity remains constant.

**Answer (B)**

**Solution:**

Potential energy is highest at maximum height.

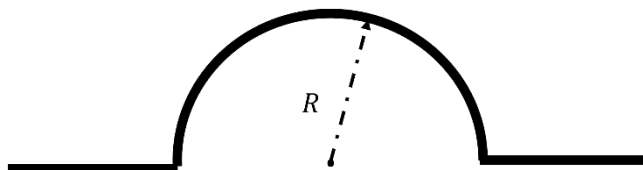
20. The electromagnetic wave, the ratio of energy carried by electric field to that by magnetic field is

**Answer (1)**

**Solution:**

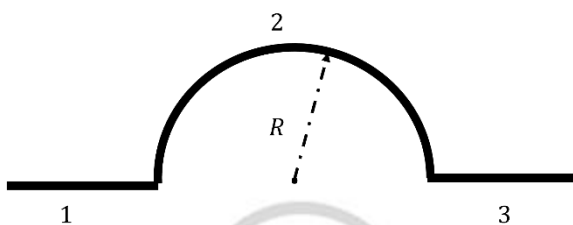
Both electric field and magnetic field carries same energy.

21. An infinite wire is bent in the shape as shown in the figure with portion  $AOB$  being semi-circular of radius  $R$ . If current  $i$  flows through the wire, then magnetic field at the centre  $O$  is equal to  $\frac{\mu_0 i}{kR}$ . Value of  $k$  is equal to



**Answer (4)**

**Solution:**



Magnetic field due to section 1 and 3 of the wire will be zero as centre is in the line of the wire, therefore field will be due to section 2 only.

Thus,

$$B = \frac{\mu_0 i}{4\pi R} \times \pi = \frac{\mu_0 i}{4R}$$

22. If a force  $F$  applied on an object moving along  $y$ -axis varies with  $y$ -coordinate as

$$F = 3 + 2y^2$$

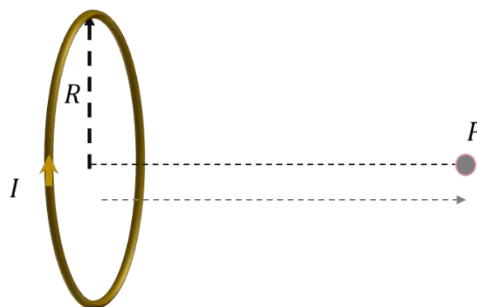
The work done in displacing the body from  $y = 2 \text{ m}$  to  $y = 5 \text{ m}$  is \_\_\_\_\_ J.

**Answer (87)**

**Solution:**

$$\begin{aligned} \text{work done} &= \int_{y_1}^{y_2} F dy \\ &= \int_2^5 (3 + 2y^2) dy \\ &= \left[ 3y + \frac{2}{3}y^3 \right] \\ &= 15 + \frac{250}{3} - 6 - \frac{16}{3} \\ &= 9 + \frac{234}{3} \\ &= 87 \text{ J} \end{aligned}$$

23. The magnetic field induced at point  $P$  on axis as shown in figure is  $\frac{\mu_0 I}{x\sqrt{5}R}$ . Find  $x$





**Answer (10)**

**Solution:**

$$\begin{aligned} B_p &= \left(\frac{\mu_0}{4\pi}\right) \left(\frac{2\mu}{(R^2 + r^2)^{\frac{3}{2}}}\right) \\ &= \left(\frac{\mu_0}{2\pi}\right) \left(\frac{I \times \pi R^2}{(R^2 + r^2)^{\frac{3}{2}}}\right) \\ &= \frac{\mu_0 I R^2}{2(R^2 + r^2)^{\frac{3}{2}}} \end{aligned}$$

As  $r = 2R$

$$B_p = \frac{\mu_0 I R^2}{2(R^2 + 4R^2)^{\frac{3}{2}}} = \frac{\mu_0 I}{10\sqrt{5} R}$$

