PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

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 velocities on the surface of planet 1 and planet 2 is equal to

(1) $\frac{\sqrt{x}}{y}$ (2) $\frac{x}{y}$

(3) $\sqrt{xy}$ (4) xy

Answer (3)

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

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

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

(1) 10.8 eV (2) 13.6 eV

(3) 12.75 eV (4) 8.6 eV

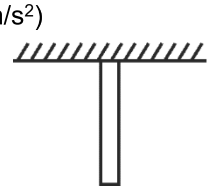
Answer (3)

Sol. $\Delta E = 13.6(1)^2 \left[1 - \frac{1}{4^2}\right] \text{eV}$

$= 13.6 \times \frac{15}{16}$ eV

= 12.75 eV

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^2 and Young's modulus is 2×10^{11} N/m^2. Find extension in the rod's length. (use g = 10 m/s^2)

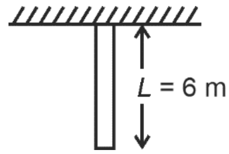


(1) 1 mm (2) 0.5 mm

(3) 0.25 mm (4) 1.2 mm

Answer (2)

Sol.



$Y = 2 \times 10^{11}$ (N/m^2)

$A = 3$ mm^2

Mass of rod = 10 kg

$\Delta L = \left(\frac{mgL}{2\Delta Y}\right) = \frac{10 \times 10 \times 6}{2 \times 3 \times 10^{-6} \times 2 \times 10^{11}}$

$= \frac{1}{2} \times 10^{-3}$ m

= 0.5 mm

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

(1) 400 K (2) 600 K

(3) 200 K (4) 300 K

Answer (1)

Sol. Let initially efficiency is x and sink temperature is T thus.

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

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

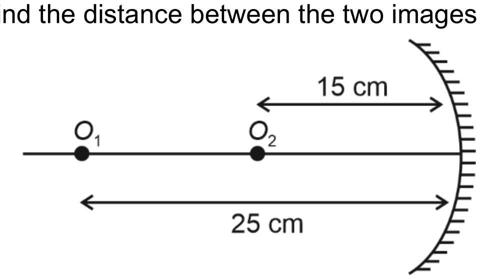
$\frac{1}{2} = \frac{1 - T/600}{1 - T/1200}$

$\frac{1}{2} - \frac{T}{2400} = I - \frac{T}{600}$

$\frac{T}{800} = \frac{1}{2}$

T = 400 K

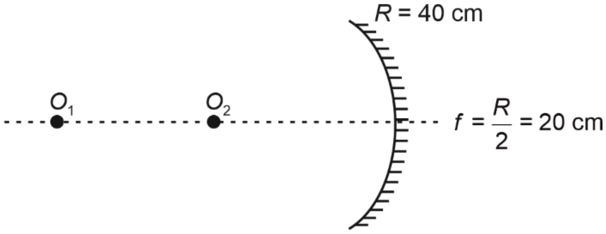
5. Two point objects O_1 and O_2 are placed on principal axis of concave mirror of radius of curvature 40 cm. Find the distance between the two images



(1) 160 cm (2) 40 cm

(3) 100 cm (4) 80 cm

Answer (1)

Sol. 

For O_1

$u = -25$ cm

$f = -20$ cm

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

$$\Rightarrow \frac{1}{v_1}=\frac{1}{f}-\frac{1}{u}=\frac{-1}{20}+\frac{1}{25}=\frac{-5+4}{100}=\frac{-1}{100}$$

$v_1 = -100$ cm

For O_2

$u = -15$ cm

$f = -20$ cm

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

$$=\frac{-3+4}{60}=\frac{-1}{60}$$

$v_2 = +60$

$|v_1 - v_2| = [60 - (-100)] = 160$ cm

6. 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 $\frac{V_1}{V_2}$

(1) 1/5

(2) 1/2

(3) 1/3

(4) 1/4

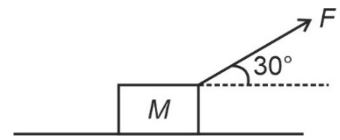
Answer (4)

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

$eV_2 = h(5f_0) - hf_0$

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

7. A block is acted upon by a force F as shown:



If M = 10 kg and coefficient of friction is 0.25, find minimum F so that block slides

(1) $\frac{200}{4\sqrt{3}+1}$N

(2) $\frac{200}{4\sqrt{3}-1}$N

(3) $\frac{100}{4\sqrt{3}+1}$N

(4) 50 N

Answer (1)

Sol. $F\sin30° + N = Mg$ ...(1)

$F\cos30° = \mu N$ ...(2)

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

8. If universal gravitational constant (G), Plank's constant (h) and speed of light (c) are taken as fundamental quantities then dimensions of mass are equal to

(1) $\sqrt{\frac{Gh}{c}}$

(2) $\sqrt{\frac{G}{hc}}$

(3) $\sqrt{\frac{h}{Gc}}$

(4) $\sqrt{\frac{hc}{G}}$

Answer (4)

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

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

$\Rightarrow y - x = 1$ ...(1)

$3x + 2y + z = 0$ ...(2)

$-2x - y - z = 0$ ...(3)

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

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

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

(1) $\frac{3}{4}mR^2$

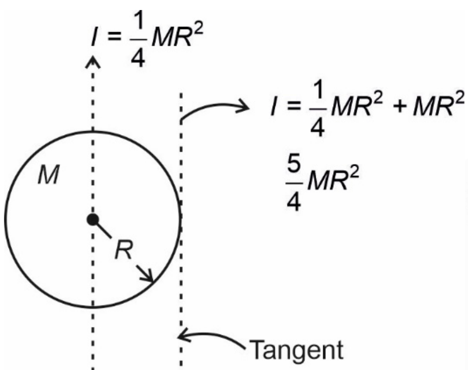
(2) $\frac{5}{4}mR^2$

(3) $\frac{3}{2}mR^2$

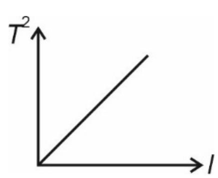
(4) $\frac{5}{2}mR^2$

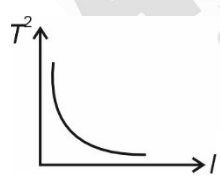
Answer (2)

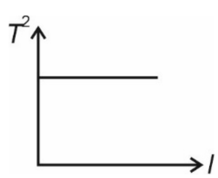
Sol.

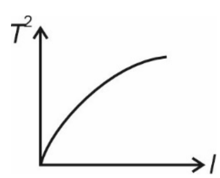


10. Which of the following graphs best represents the relation between square of time period and length of a simple pendulum?

(1)


(2)


(3)


(4)


Answer (1)

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

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

Thus the graph between T^2 and l is a straight line passing from origin.

11. 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.

(1) $\frac{n-1}{n}R$

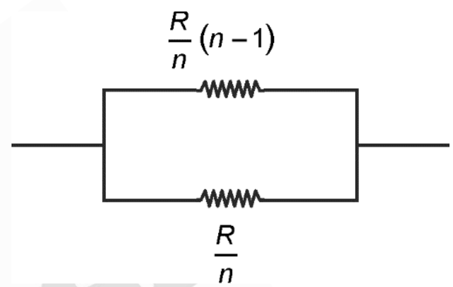
(2) $\frac{n-1}{n^2}R$

(3) $\frac{n-1}{n^3}R$

(4) $\frac{n+1}{n^2}R$

Answer (2)

Sol.



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

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

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

12. Which of the following is correct for zener diode?

a. It acts as voltage regulator

b. It is used in forward bias

c. It is used in reverse bias

d. It is used as switch in series

(1) a and d

(2) b and c

(3) a and c

(4) b and d

Answer (3)

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

13. 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?

(1) 125 m

(2) 500 m

(3) 250 m

(4) 400 m

Answer (3)

Sol. The train needs 500 m to stop.

$\Rightarrow$ It would move beyond the station by

(500 – 250) m = 250 m.

14. For a Carnot engine working between source (at temperature T_H) and sink (at temperature T_L), efficiency is $\frac{1}{3}$. By how much amount should the sink temperature be increased so that efficiency becomes $\frac{1}{6}$?

Given T_H = 600 K

(1) 100 K

(2) 50 K

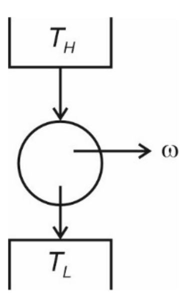
(3) 25 K

(4) 125 K

Answer (1)

Sol. $\eta = 1 - \frac{T_L}{T_H} = \frac{1}{3}$

$$\frac{T_L}{T_H} = \frac{2}{3}$$



Now, temperature of sink is increased

$$1 - \frac{T_L + x}{T_H} = \frac{1}{6}$$

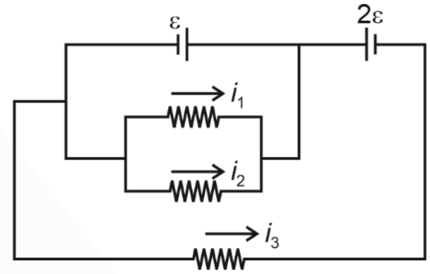
$$\Rightarrow \frac{T_L + x}{T_H} = \frac{5}{6}$$

$$\Rightarrow \frac{x}{T_H} = \frac{5}{6} - \frac{2}{3} = \left(\frac{1}{6}\right)$$

As T_H = 600 K

so, $x = \frac{T_H}{6} = 100\ \text{K}$

15. Consider the following circuit:



All resistors have resistance 10 Ω each.

Find $\left|\frac{i_1 + i_2}{i_2}\right|$

(1) 2

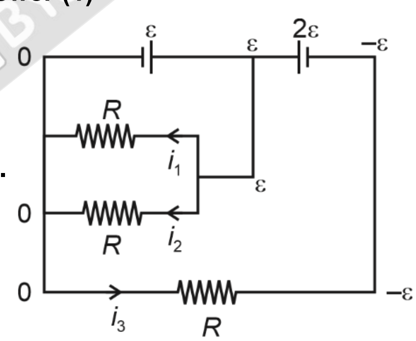
(2) 1

(3) 3

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

Answer (1)

Sol.



$$i_1 = \frac{\varepsilon}{R}$$

$$i_2 = \frac{\varepsilon}{R}$$

$$i_3 = \frac{\varepsilon}{R}$$

$$\frac{i_1 + i_2}{i_3} = \frac{\frac{2\varepsilon}{R}}{\frac{\varepsilon}{R}} = 2$$

16. **Assertion :** For making a voltmeter, we prefer a voltmeter of resistance of 400 Ω over a voltmeter of resistance of 1000 Ω.

Reason : Voltmeter should be of high resistance such that it draws less current from circuit.

(1) A and R both true R is correct explanation of A

(2) A and R both true but R is not the correct explanation of A

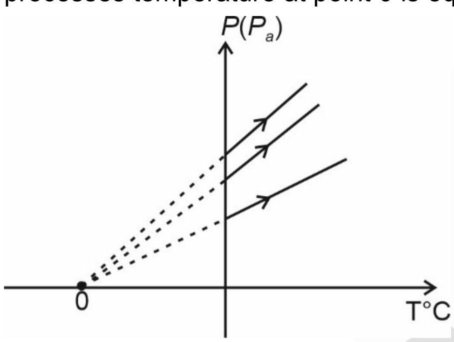
(3) A is true but R is false

(4) A is false but R is true

Answer (1)

Sol. 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 difference. To avoid this we choose higher resistance.

17. According to the shown *P*-*T* graph of three processes temperature at point 0 is equal to



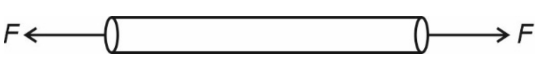
(1) –0°C (2) –373°C

(3) 100°C (4) –273°C

Answer (4)

Sol. All the gases will cease to exist at –273°C therefore the pressure will be zero so the temperature of point 0 is –273°C

18. 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:

$F = 100$ N $A = 10$ cm^2

$l = 1$ m $Y = 5 \times 10^{10}$ N/m^2

(1) 10^{-6} m

(2) 10^{-5} m

(3) 2×10^{-6} m

(4) 2×10^{-5} m

Answer (3)

Sol. $\Delta l = \dfrac{Fl}{Ay}$

$= 2 \times 10^{-6}$ m

19. In a YDSE setup, if a mica sheet of thickness '*t*' and refractive index μ is inserted in front of one of the slits. Find the number of fringes by which the central fringe gets shifted

[Given λ, *D* and *d* are wavelength of light, distance between slits and screen and slit separation respectively]

(1) $\dfrac{\mu t}{\lambda}$ (2) $\dfrac{(\mu-1)t}{\lambda}$

(3) $\dfrac{(\mu+1)t}{\lambda}$ (4) $\dfrac{(2\mu-1)t}{\lambda}$

Answer (2)

Sol. Path difference due to mica sheet = $(\mu - 1)t$

$$\text{Number of fringes shift} = \frac{\dfrac{[(\mu-1)tD]}{d}}{\left(\dfrac{\lambda D}{D}\right)}$$

$$= \frac{(\mu-1)t}{\lambda}$$

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

(1) Kinetic energy is zero at highest point.

(2) Potential energy is highest at highest point.

(3) Horizontal component of velocity increases.

(4) Vertical component of velocity remains constant.

Answer (2)

Sol. Potential energy is highest at maximum height.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

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

$F = 3 + 2y^2$

The work done in displacing the body from $y = 2$ m to $y = 5$ m is ______J.

Answer (87.00)

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

Work done = $\int F dy$

$$= \int_2^5 \left(3 + 2y^2\right) dy$$

$$= \left[3y + \frac{2}{3}y^3\right]_2^5$$

$$= 15 + \frac{250}{3} - 6 - \frac{16}{3}$$

$$= 9 + \frac{234}{3}$$

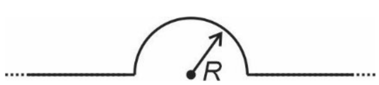
$$= \frac{27 + 234}{3} = \frac{261}{3} = 87 \text{ J}$$

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

Answer (01.00)

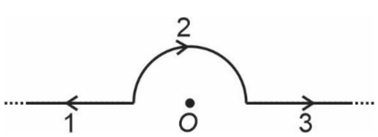
Sol. Both carry same energy.

23. 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 (04.00)

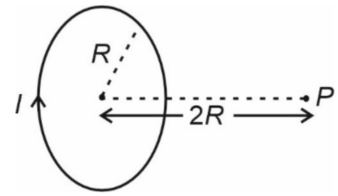
Sol.



Magnetic field due to section 1 and 3 of the wire will be zero at O is in line to the wire, therefore field will be due to section 2 only thus $B = \frac{\mu_0 i}{4\pi R} \times \pi = \frac{\mu_0 i}{4R}$

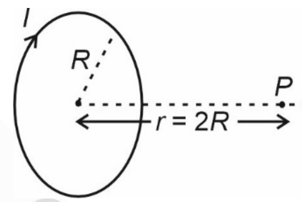
24. The magnetic field induction at point P on axis as shown in figure is $\frac{\mu_0 I}{x\sqrt{5}R}$.

Find x



Answer (10.00)

Sol.



$$B_P = \left(\frac{\mu_0}{4\pi}\right) \frac{(2\mu)}{\left(R^2 + r^2\right)^{3/2}}$$

$$= \frac{\mu_0}{2\pi} \frac{I \times \pi R^2}{\left(R^2 + r^2\right)^{3/2}}$$

$$= \frac{\mu_0 I R^2}{2\left(R^2 + r^2\right)^{3/2}}$$

as $r = 2R$

$$= \frac{\mu_0 I R^2}{2\left(R^2 + 4R^2\right)^{3/2}}$$

$$= \left(\frac{\mu_0 I}{10\sqrt{5}R}\right)$$

25. ??

26. ??

27. ??

28. ??

29. ??

30. ??