DAY FOURTY

# Mock Test 3

## (Based on Complete Syllabus)

### Instructions

1. This question paper contains of 30 Questions of Physics, divided into two Sections :
   SECTION A OBJECTIVE TYPE QUESTIONS AND SECTION B NUMERICAL TYPE QUESTIONS.
2. Section A contains 20 Objective questions and all Questions are compulsory (**Marking Scheme** : Correct +4, Incorrect −1).
3. Section B contains 10 Numerical value questions out of which only 5 questions are to be attempted (**Marking Scheme** : Correct +4, Incorrect 0).

### Section A : Objective Type Questions

**1** An organ pipe of length $L_0$, open at both ends is bound to vibrate in its first harmonic, when sounded with a tuning fork of 480 Hz. What should be the length of a pipe closed at one end, so that it also vibrates in its first harmonic with the same tuning fork?

(a) $L_c = 2L_0$ (b) $L_c = \frac{L_0}{3}$ (c) $L_c = \frac{L_0}{2}$ (d) $L_c = \frac{2L_0}{3}$

**2** Choose the correct alternative.

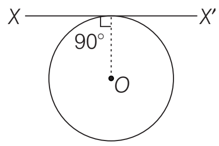
(a) Gravitational potential at curvature centre of a thin hemispherical shell of radius $R$ and mass $M$ is equal to $GM/R$

(b) Gravitational field strength at a point lying on the axis of a thin uniform circular ring of radius $R$ and mass $M$ is equal to $\frac{GM}{(R^2 + x^2)^{3/2}}$, where $x$ is distance of that point from centre of the ring

(c) Newton's law of gravitation for gravitational force between two bodies is applicable only, when bodies have spherically symmetric distribution of mass

(d) None of the above

**3** A thin wire of length $L$ and uniform linear mass density $\rho$ is bent into a circular loop with centre at $O$ as shown. The moment of inertia of the loop about the axis $XX'$ is




(a) $\frac{\rho L^3}{8\pi^2}$ (b) $\frac{\rho L^3}{16\pi^2}$

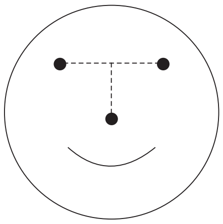
(c) $\frac{5\rho L^3}{16\pi^2}$ (d) $\frac{3\rho L^3}{8\pi^2}$

**4** If a drop of liquid breaks into smaller droplets, it results in lowering of temperature of the droplets. Let a drop of radius $R$, break into $N$ small droplets each of radius $r$. Estimate the temperature in drop.

(a) $\frac{S}{\rho s}\left[\frac{1}{R}\right]$ (b) $\frac{2S}{\rho s}\left[\frac{1}{r} - \frac{1}{R}\right]$

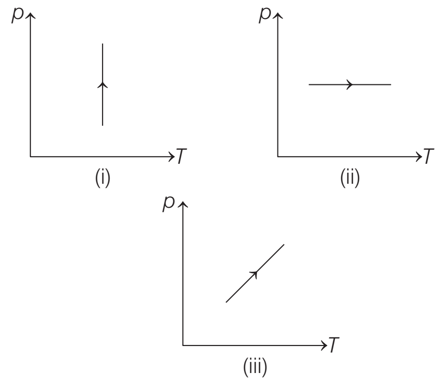
(c) $\frac{3S}{\rho s}\left[\frac{1}{R} - \frac{1}{r}\right]$ (d) $\frac{2S}{\rho s}\left[\frac{1}{R} - \frac{1}{r}\right]$

**5** The smiling face in figure consists of three items (i), A thin rod of charge $-3.0\,\mu C$ that forms a full circle of radius 6 cm. (ii) second thin rod of charge $2.0\,\mu C$ that forms a circular arc of radius 4.0 cm, subtending an angle of 20° about the centre of the full circle and (iii) electric dipole with a dipole moment that is $\perp$ to a radial line and has a magnitude $1.28 \times 10^{-21}$cm, what is the net electric potential of the centre.



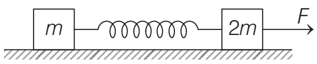
(a) zero
(b) $2.3 \times 10^{-3}$
(c) $1.28 \times 10^{21}$
(d) None of these

**6** Pressure *versus* temperature graphs of an ideal gas are as shown in figure. Choose the incorrect statement.




(a) Density of gas is increasing in graph (i)
(b) Density of gas is increasing in graph (ii)
(c) Density of gas is constant in graph (iii)
(d) None of the above

**7** **Assertion** (A) A constant force $F$ is applied on the two blocks and one spring system as shown in the figure. Velocity of centre of mass increases linearly with time.

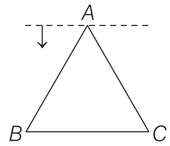



**Reason** (R) Acceleration of centre of mass is constant.

(a) Both A and R are correct and R is the correct explanation of A.
(b) Both A and R are correct but R is not the correct explanation of A.
(c) A is correct but R is not correct.
(d) A is not correct but R is correct.

**8** **Assertion** (A) There is a triangular plate as shown in the figure A dotted axis is lying in the plane of the slab. As the axis is moved downwards, moment of inertia of the slab will first decreases, then increases.

**Reason** (R) Axis is first moving towards its centre of mass, then it is receding from it.

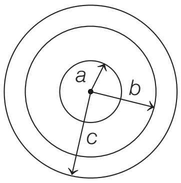



In the light of the above statements, choose the most appropriate answer from the options given below.

(a) Both A and R are correct and R is the correct explanation of A.
(b) Both A and R are correct but R is not the correct explanation of A.
(c) A is correct but R is not correct.
(d) A is not correct but R is correct.

**9** A solid conducting sphere of radius $a$ has a net positive charge $2Q$. A conducting spherical shell of inner radius $b$ and outer radius $c$ is concentric with the solid sphere and has a net charge $-Q$.

The surface charge density on the inner and outer surfaces of the spherical shell will be




(a) $-\frac{2Q}{4\pi b^2}, \frac{Q}{4\pi c^2}$
(b) $-\frac{Q}{4\pi b^2}, \frac{Q}{4\pi c^2}$
(c) $0, \frac{Q}{4\pi c^2}$
(d) None of these

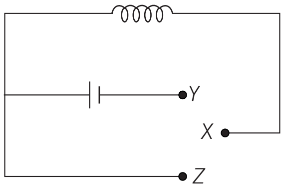
**10** **Statement I** Time period of oscillation of two magnets, when like poles are in same direction (in a vibration magnetometer) is smaller, than the period of vibration when like poles are in opposite direction.

**Statement II** Moment of inertia increases in same position.

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

(a) Statement I is true but Statement II is false.
(b) Both Statement I and Statement II are true.
(c) Both Statement I and Statement II are false.
(d) Statement I is false but Statement II is true.

**11** In the circuit shown, the coil has inductance and resistance. When $X$ is joined to $Y$, the time constant is $\tau$ during growth of current. When the steady state is reached, heat is produced in the coil at a rate $P$. $X$ is now joined to $Z$

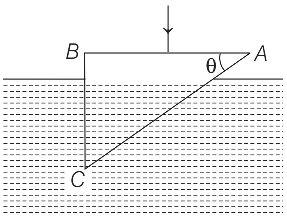



(a) the total heat produced in the coil is $P\tau$
(b) the total heat produced in the coil is $\frac{1}{2}P\tau$
(c) the total heat produced in the coil is $2P\tau$
(d) the data given is not sufficient to reach a conclusion

**12** Nickle shows ferromagnetic property at room temperature. If the temperature is increased beyond curie temperature, then it will show

(a) anti-ferromagnetism
(b) no magnetic property
(c) diamagnetism
(d) paramagnetism

**13** A glass prism *ABC* (refractive index 1.5), immersed in water (refractive index 4/3). A ray of light is incident normally on face *AB*. If it is totally reflected at face *AC*, then




(a) $\sin\theta \geq \frac{8}{9}$

(b) $\sin\theta \geq \frac{2}{3}$

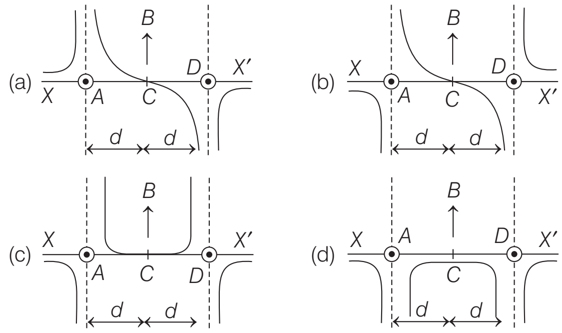
(c) $\sin\theta = \frac{\sqrt{3}}{2}$

(d) $\frac{2}{3} < \sin\theta < \frac{8}{9}$

**14** In a given process of an ideal gas, $dW = 0$ and $dQ < 0$. Then, for the gas

(a) the temperature will decrease
(b) the volume will increase
(c) the pressure will remain constant
(d) the temperature will increase

**15** Two long parallel wires are at a distance $2d$ apart. They carry steady equal currents flowing out of the plane of the paper, as shown. The variation of the magnetic field *B* along the line *XX′* is given by

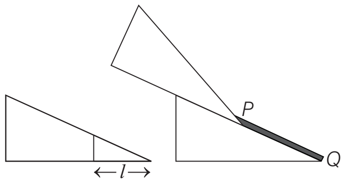



**16** Two radioactive nuclei *A* and *B* have their disintegration constant $\lambda_A$ and $\lambda_B$, respectively. Initially, $N_A$ and $N_B$ number of nuclei are taken, then the time after which their undisintegrated nuclei are same is

(a) $\frac{\lambda_A\lambda_B}{(\lambda_A - \lambda_B)} \ln\left(\frac{N_B}{N_A}\right)$
(b) $\frac{1}{(\lambda_A + \lambda_B)} \ln\left(\frac{N_B}{N_A}\right)$

(c) $\frac{1}{(\lambda_B - \lambda_A)} \ln\left(\frac{N_B}{N_A}\right)$
(d) $\frac{1}{(\lambda_A - \lambda_B)} \ln\left(\frac{N_B}{N_A}\right)$

**17** A student constructed a vernier callipers as shown in the figure. He used two identical inclines and tried to measure the length of line *PQ*. For this instrument determine the least count.




(a) $\frac{l(1-\cos\theta)}{\cos\theta}$ units

(b) $\frac{l}{\cos\theta}$ units

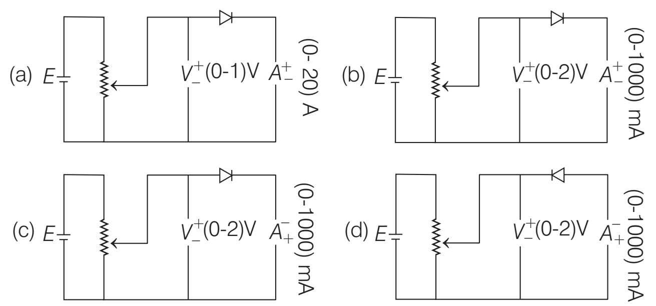
(c) $l(1-\cos\theta)$ units

(d) $\frac{1-\cos\theta}{l}$ units

**18** A double star consists of two stars having masses $M$ and $2M$. The distance between their centres is equal to $r$. They revolve under their mutual gravitational interaction. Then, which of the following statement(s) is/are correct?

(a) Heavier star revolves in orbit of radius $2r/3$
(b) Both of the stars revolve with the same period which is equal to $\frac{2\pi}{\sqrt{2GM/3}} r^{3/2}$
(c) Kinetic energy of heavier star is twice that of the other star
(d) None of the above

**19** To plot forward characteristic of $p$-$n$ junction diode, the correct circuit diagram is




**20** For atomic model of hydrogen atom given by Niels Bohr, match the following proportionalities.

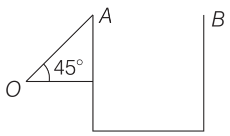
| | Column I | | Column II |
|---|---|---|---|
| A. | Angular momentum | 1. | $1/n$ |
| B. | Velocity of electron | 2. | $n^2$ |
| C. | Radius of electron | 3. | $1/n^2$ |
| D. | Energy of electron | 4. | $n$ |

| | A | B | C | D |
|---|---|---|---|---|
| (a) | 1 | 2 | 3 | 4 |
| (b) | 4 | 3 | 2 | 1 |
| (c) | 4 | 1 | 3 | 2 |
| (d) | 4 | 1 | 2 | 3 |

## Section B : Numerical Type Questions

**21** A hill is 500 m high. Supplies are to be sent across the hill using a canon that can hurl packets at a speed of 125 $ms^{-1}$ over the hill. The canon is located at a distance of 800 m from the foot of hill and can be moved on the ground at a speed of 2 $ms^{-1}$, so that its distance from the hill can be adjusted. What is the shortest time (in s) in which a packet can reach on the ground across the hill? (Take, $g = 10\ ms^{-2}$)

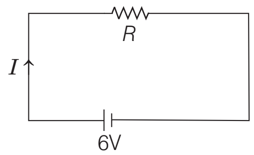
**22** A motor cyclist starts from the bottom of a slope of angle 45° and travels along the slope to jump clear of the valley $AB$ as shown in figure. The width of the valley is 160 m and the length of the slope is $160\sqrt{2}$ m. The minimum velocity with which he should leave the bottom $O$, so that he can clear the valley, is (nearest to in $ms^{-1}$)




**23** A man beats a drum at a certain distance from a mountain. He slowly increase the rate of beating and finds that the echo is not heard distinctly, when the drum beating is at the rate of 40 per min. He moves by 80 m towards the mountain and finds that the echo is again not heard distinctly, when the rate of beating of the drum is 1 per sec. What is the original distance (in m) of the man from the mountain?

**24** A metal wire of linear mass density of 9.8 $gm^{-1}$ is stretched with a tension of 10 kg-wt between two rigid supports which are 1m apart. The wire passes through the middle points between the poles of a permanent magnet and it vibrates in resonance, when carrying on alternating current of frequency $n$. The frequency $n$ of the alternating current (in Hz) is ...... .

**25** The circuit shown in figure, contains a resistance of $R = 6\,\Omega$ connected with a battery of emf 6 V.



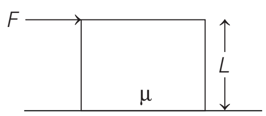

Given, $n$ = number of electrons per volume $= 10^{29}/m^3$, length of circuit = 10 cm, cross-section $A = 1\,mm^2$. The energy absorbed by electrons from initial state of no current (ignore thermal motion) to the state of drift velocity is found to be $x \times 10^{-17}$ J, then the value of $x$ is ...... .

**26** The potential energy of a particle of mass $m$ is given by

$$U(x) = \begin{cases} E_0 & 0 \le x \le 1 \\ 0 & x > 1 \end{cases}$$

$\lambda_1$ and $\lambda_2$ are the de-Broglie wavelengths of the particle, when $0 \le x \le 1$ and $x > 1$, respectively. If the total energy of particle is $2E_0$. If the value of the ratio $\frac{\lambda_1}{\lambda_2}$ is $\frac{\sqrt{x}}{1}$, then the value of $x$ is ...... .

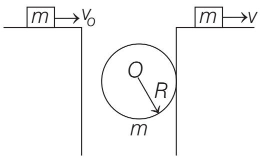
**27** A cubical block of side $L$ rests on a rough horizontal surface with coefficient of friction $\mu$. A horizontal force $F$ is applied on the block as shown in the figure. If the coefficient of friction is sufficiently high, so that the block does not slide before toppling, the minimum force required to topple the block is found to be $nmg$, then the value of $n$ is ...... .




**28** The fundamental frequency of a sonometer wire of length $l$ is $f_0$. A bridge is now introduced at a distance of $\Delta l$ from the centre of the wire ($\Delta l << l'$). The number of beats heard, if both sides of the bridges are set into vibration in their fundamental modes, are found to be $\frac{bf_0 \Delta l}{l}$, then find the value of $b$.

**29** A mason is supplied with bricks by his assistant who is 3 m below him, the assistant is tossing the brick vertically up. The speed of the brick, when it reaches the mason is 2 $ms^{-1}$. What percentage of energy used up by the servant serves no useful purpose ?

**30** A block of mass $m$ moves with a velocity $v_o$ on a smooth horizontal surface. If that passes over a cylinder of radius $R$ and mass $m$, capable of rotating about its own fixed axis through $O$ the block, while passing over, slips on the cylinder. The slipping stops before, it loses contact. The block then moves on similar smooth horizontal surface with a velocity $v$. then the velocity $v$ in terms of $v_0$ is found to be $\frac{2v_0}{m}$, then find the value of $m$.

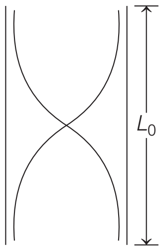



# ANSWERS

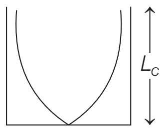
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** (c) | **2.** (c) | **3.** (d) | **4.** (c) | **5.** (a) | **6.** (a) | **7.** (a) | **8.** (a) | **9.** (a) | **10.** (a) |
| **11.** (b) | **12.** (d) | **13.** (a) | **14.** (a) | **15.** (b) | **16.** (c) | **17.** (a) | **18.** (b) | **19.** (b) | **20.** (d) |
| **21.** (45) | **22.** (70) | **23.** (240) | **24.** (50) | **25.** (2) | **26.** (2) | **27.** (0.5) | **28.** (8) | **29.** (5.6) | **30.** (3) |

# Hints and Explanations

**1** The fundamental frequency for an open pipe, $\nu_0 = \dfrac{\nu}{2L_0}$




Open organ pipe




Closed organ pipe

Fundamental frequency for closed pipe,

$$\nu_0' = \frac{\nu}{4L_c}$$

According to the question,

$$\nu_0 = \nu_0'$$

$$\frac{\nu}{2L_0} = \frac{\nu}{4L_0} \Rightarrow L_c = \frac{L_0}{2}$$

**2** Because every element of hemispherical shell is at a distance **R** from centre of curvature, therefore gravitational potential at its centre $= -\dfrac{GM}{R}$,

i.e. option (a) is incorrect.

Gravitational field strength at a point, lying on the axis of a thin uniform circular ring of radius **R** is $\dfrac{GMx}{(R^2 + x^2)^{3/2}}$

So, option (b) is incorrect.

Newton's law of gravitation is applicable to only those bodies which have spherically symmetric distribution of mass. So, option (c) is correct.

**3** Mass of the ring, $M = \rho L$

Let **R** be the radius of the ring.

Then, $L = 2\pi R$ or $R = \dfrac{L}{2\pi}$

Moment of inertia about **XX′** (from parallel axis theorem) will be given by

$$I_{XX'} = \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$$

Putting values of **M and R**,

$$I_{XX'} = \frac{3}{2}(\rho L)\left(\frac{L^2}{4\pi^2}\right) = \frac{3}{8}\frac{\rho L^3}{\pi^2}$$

**4** When a big drop of radius *R*, break into *N* droplets each of radius *r*, the volume remains constant.

∴ Volume of big drop

= N × volume of small drop

$$\frac{4}{3}\pi R^3 = N \times \frac{4}{3}\pi r^3$$

or $\quad R^3 = Nr^3$ or $N = \dfrac{R^3}{r^3}$

Now, change in surface area

$$= 4\pi R^2 - N4\pi r^2$$
$$= 4\pi(R^2 - Nr^2)$$

Energy released $= S \times \Delta A$

(where, *S* = surface tension)

$$= S \times 4\pi(R^2 - Nr^2)$$

Due to release of this energy, the temperature is lowered.

If ρ is the density and *s* is specific heat of liquid and its temperature is lowered by Δθ then,

Energy released $= ms\Delta\theta$

$$S \times 4\pi(R^2 - Nr^2) = \left(\frac{4\pi}{3} \times R^3 \times \rho\right)s\Delta\theta$$

$$\Delta\theta = \frac{S \times 4\pi(R^2 - Nr^2)}{\frac{4}{3}\pi R^3 \rho \times s}$$

$$= \frac{3S}{\rho s}\left[\frac{R^2}{R^3} - \frac{Nr^2}{R^3}\right]$$

$$= \frac{3S}{\rho s}\left[\frac{1}{R} - \frac{(R^3/r^3) \times r^2}{R^3}\right]$$

$$= \frac{3S}{\rho s}\left[\frac{1}{R} - \frac{1}{r}\right]$$

**5** The dipole potential $(\theta = 90°)$ is given by the equation,

$$V = \frac{p\cos\theta}{4\pi\varepsilon_0 r^2} = \frac{p\cos 90°}{4\pi\varepsilon_0 r^2} = 0$$

$[\because \cos 90° = 0]$

Also, the potential due to the short arc is $q_1 / 4\pi\varepsilon_0 r_1$ and that caused by the long arc is $q_2 / 4\pi\varepsilon_0 r^2$.

Since, $q_1 = +2\mu C$, $r_1 = 4$ cm, $q_2 = -3\mu C$ and $r_2 = 6$ cm, the potential of the arcs cancel.

Thus, the result is zero.

**6** As, $\rho = \dfrac{pM}{RT}$

Density ρ remains constant, when $p/T$ or volume remains constant. In graph (i) volume is decreasing, hence density is increasing; while in graphs (ii) and (iii) temperature is increasing, hence, density is decreasing. Note that, volume would have been constant in case the straight line in graph (iii) had passed through origin.

**7** Total mass of the system

$$= m + 2m = 3m$$

Force applied on the system is **F**.

$$\therefore\ a_{CM} = \frac{F}{3m}$$

= constant as **F** is constant

$$\therefore\ v_{CM} = a_{CM} \times t$$

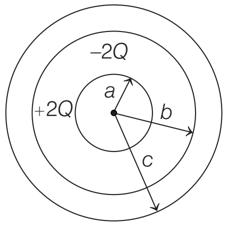
or $v_{CM} = \dfrac{F}{3m} \times t$ or $v_{CM} \propto t$

Hence, both Assertion and Reason are correct and the Reason is the correct explanation of Assertion.

**8** Moment of inertia $(I) = mr^2$, where **r** is distance from the axis of rotation to the centre of mass. When dotted axis moved downward (towards centre of mass), **r** decreases result moment of inertia decrease and when dotted axis cross the centre of mass and moved further downwards, then **r** increases result moment of inertia increases.

Hence, both Assertion and Reason are correct and the Reason is the correct explanation of Assertion.

**9** Due to induction, inner surface of spherical shell has charge $-2Q$,




So, surface charge density on inner side

$$\sigma_{inner} = \frac{-2Q}{4\pi b^2}$$

and surface charge density on outer side

$$\sigma_{outer} = \frac{Q}{4\pi c^2}$$

**10** ***Case* I** When the like poles of two magnets are placed in same direction, then the time period of vibration is expressed as

$$T' = 2\pi\sqrt{\frac{I_1 + I_2}{(M_1 + M_2)B}} \qquad \ldots(i)$$

***Case* II** When the like poles of two magnets are placed in opposite direction, then period of vibration is expressed as

$$T'' = 2\pi\sqrt{\frac{I_1 + I_2}{(M_1 - M_2)B}} \qquad \ldots(ii)$$

It is clear from Eqs. (i) and (ii) that, $T' < T''$.

**11** As, $P = (I_0)^2 \cdot R$

i.e. $(I_0)^2 = \dfrac{P}{R}$

$\therefore \quad U = \frac{1}{2} LI_0^2 = \frac{1}{2}(\tau R)\left(\frac{P}{R}\right) = \frac{1}{2} P\tau$

**12** The curie temperature is defined as the temperature beyond which the ferromagnetic material shows paramagnetic behaviour.

**13** For total internal reflection at **AC**-face

$$\sin i \geq \frac{\mu_w}{\mu_g}$$

$$\sin\theta \geq \frac{4}{3 \times 1.5}$$

$$\sin\theta \geq \frac{8}{9}$$

**14** From first law of thermodynamics

$$dQ = dU + dW$$

$$dQ = dU \qquad (\because dW = 0)$$

Since, $dQ < 0$

Therefore, $dU < 0$

or $U_{final} < U_{initial}$

or temperature will decrease.

**15** If the current flows out of the paper, the magnetic field at points to the right of the wire will be upwards and to the left will be downward. Now, magnetic field at **C** is zero. The field in the region **DX′** will be upwards (+ve), because all points existing in this region are to the right of both the wires. Similarly, magnetic field in the region **AX** will be downwards (–ve). The field in the region **AC** will be upwards (+ve), because points are closer to **A** as compared to **D**. Similarly, magnetic field in region **DC** will be downward (–ve).

**16** After disintegration,

$N_A e^{-\lambda_A t} = N_B e^{-\lambda_B t}$ (for $0 \leq x \leq 1$)

or $e^{(\lambda_B - \lambda_A)t} = \frac{N_B}{N_A}$ ...(i)

$$\therefore (\lambda_B - \lambda_A) t = \ln\left(\frac{N_B}{N_A}\right)$$

$$\Rightarrow \quad t = \frac{1}{\lambda_B - \lambda_A} \ln\left(\frac{N_B}{N_A}\right)$$

**17** Let θ be the angle of incline. Here, the incline kept horizontally is working as main scale while the other incline kept on horizontally placed incline is treated as vernier scale.

From the figure, it is clear that,

1 MSD = $\frac{l}{\cos\theta}$ unit and 1 VSD = $l$ unit

So, LC of instrument is,

**LC = 1MSD – 1 VSD**

$$= \left(\frac{l}{\cos\theta} - l\right) = \frac{l(1-\cos\theta)}{\cos\theta} \text{ units}$$

**18** The centre of mass of the double star system remains stationary and both the stars revolve round in circular orbits, which are concentric with the centre of mass.

The distance of centre of mass from the heavier star = $\frac{Mr + 2M \times 0}{M + 2M} = \frac{r}{3}$

Hence, the heavier star revolves in a circle of radius $\frac{r}{3}$ while the lighter star in a circle of radius $\frac{2r}{3}$.

Reduced mass of the system = $\frac{M \cdot 2M}{M + 2M} = \frac{2M}{3}$

Period of revolution of the double star system = $\frac{2\pi}{\sqrt{\frac{2GM}{3}}} r^{3/2}$

where, **r** is the distance between two stars.

KE of a star = $\frac{1}{2} mv^2$

KE of heavier star

$$E_1 = \frac{1}{2} \times 2M \times \left(\frac{r}{3}\omega\right)^2$$

and that of lighter star

$$E_2 = \frac{1}{2} M \left(\frac{2r}{3}\omega\right)^2$$

So, kinetic energy of lighter star is two times that of heavier star.

**19** For forward bias mode the **p**-side of diode has to be at higher potential than **n**-side. The meters used are DC, so we have to be careful while connecting them w.r.t. polarity.

Last point is to decide the range of meters, the range of meters has to be in such a way that we can have the readings which leads to plot on realistic scale. If we take 0-20 A ammeter, then reading we read from this is tending to 0 to 5 divisions which is not fruitful.

**20** A → 4, B → 1, C → 2, D → 3

As we know, angular momentum

$$(L) = \frac{nh}{2\pi} \Rightarrow L \propto n$$

Radius of an electron = $r_n = \frac{n^2}{m}\left(\frac{h}{2\pi}\right)^2 \frac{4\pi\varepsilon_0}{e^2} \Rightarrow r_n \propto n^2$

Velocity of electrons

$$v_n = \frac{1}{n}\frac{e^2}{4\pi\varepsilon_0} \cdot \frac{1}{(h/2\pi)}$$

$$v_n \propto 1/n$$

Potential energy **i.e.**, $E_n = -\frac{me^4}{8n^2\varepsilon_0^2h^2}$

$$\therefore \quad E_n \propto 1/n^2$$

**21** Given, height of the hill ($h$) = **500** m

Velocity of canon, $u = 125 \text{ ms}^{-1}$

To cross the hill, the vertical component of the velocity should be sufficient to cross such height.

$$\therefore u_y \geq \sqrt{2gh} \geq \sqrt{2 \times 10 \times 500}$$

$$\geq 100 \text{ ms}^{-1}$$

But $u^2 = u_x^2 + u_y^2$

∴ Horizontal component of initial velocity,

$$u_x = \sqrt{u^2 - u_y^2} = \sqrt{(125)^2 - (100)^2}$$

$$= 75 \text{ ms}^{-1}$$

Time taken to reach the top of the hill,

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 500}{10}} = 10 \text{ s}$$

Time taken to reach the ground from the top of the hill,

$$t' = t = 10 \text{ s}$$

Horizontal distance travelled in 10 s,

$$x = u_x \times t$$

$$= 75 \times 10 = 750 \text{ m}$$

∴ Distance through which canon has to be removed = **800** – **750** = **50** m

Speed with which canon can move

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

∴ Time taken by canon = $\frac{50}{2}$

$$t'' = 25 \text{ s}$$

Hence, total time taken by a packet to reach on the ground = $t'' + t + t'$

$$= 25 + 10 + 10$$

$$= 45 \text{ s}$$

**22** Velocity to take-off from **A** to clear the valley is given by

$$R = \frac{u^2}{g}\sin 2\alpha$$

$$\alpha = 45°, \; u = \sqrt{gR} = 40 \text{ ms}^{-1}$$

Velocity to start from lowest point (due to retardation on inclined plane, **g sin** α),

$$v_0^2 = u^2 + 2g\sin\alpha \times s$$

$$\therefore \quad v_0 = \sqrt{(40)^2 + 2 \times 10 \times \frac{1}{\sqrt{2}} \times 160 \times \sqrt{2}}$$

$$= \sqrt{4800} \simeq 70 \text{ ms}^{-1}$$

**23** The echo is not heard distinctly, when the echo and the next beat fall on the ear simultaneously, i.e. time per beat = time taken by the reflected beat to reach the man.

Hence, $\frac{2d}{v} = \frac{60}{40} = \frac{3}{2}$

and $\frac{2(d-80)}{v}=1$

This gives, $d = 240$ m

**24** Since, the tension,

$T = 10$ kg-wt $= 10 \times 9.8 = 98$ N

and $m = 9.8 \times 10^{-3}$ kgm$^{-1}$, $L = 1$m

So, we get

$$n = \frac{1}{2L}\sqrt{\frac{T}{m}} = \frac{1}{2\times 1}\times\sqrt{\frac{98}{9.8\times 10^{-3}}}$$

$= 50$ Hz

**25** Given, $V = 6$ V, $R = 6\ \Omega$,

$A = 1 \times 10^{-6}$ m$^2$

and $l = 10$ cm $= 0.1$ m

The current in the circuit,

$$I = \frac{V}{R} = \frac{6}{6} = 1\text{ A}$$

Use the relation $I = neAv_d$

Drift velocity of electrons,

$$v_d = \frac{I}{neA}$$

$$= \frac{1}{10^{29}\times 1.6\times 10^{-19}\times 1\times 10^{-6}}$$

$$= \frac{1}{1.6}\times 10^{-4}\text{ms}^{-1}$$

The energy of electrons, (KE) $= \frac{1}{2}mv^2$

$= \frac{1}{2}\times m_e \times v_d^2 \times$ volume $\times$ number of electrons per volume

$$= \frac{1}{2}\times 9.1\times 10^{-31}\times\left(\frac{10^{-4}}{1.6}\right)^2\times A\times I\times n$$

($\because$ Mass of electron $m_e = 9.1\times 10^{-31}$)

$$= \frac{9.1\times 10^{-39}}{2\times 1.6\times 1.6}\times 10^{-6}\times 0.1\times 10^{29}$$

$= 2\times 10^{-17}$ J

$\therefore x = 2$

**26** $KE = 2E_0 - E_0 = E_0$ (for $0 \le x \le 1$)

So, $\lambda_1 = \frac{h}{\sqrt{2mE_0}}$ ...(i)

Again $KE = 2E_0$ (for $x > 1$)

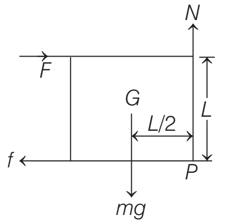
$\therefore$ $\lambda_2 = \frac{h}{\sqrt{2m2E_0}}$ ...(ii)

From Eqs. (i) and (ii), we get

$$\frac{\lambda_1}{\lambda_2} = \sqrt{2} = \sqrt{x} \quad \text{(given)}$$

$\therefore$ $x = 2$

**27** At the critical condition, normal reaction **N** will pass through point **P**.




The block will topple when

$$\tau_F > \tau_{mg} \text{ or } FL > (mg)\frac{L}{2}$$

$\therefore$ $F > \frac{mg}{2}$

Therefore, the minimum force required to topple the block is $F = \frac{mg}{2}$.

$= 0.5\ mg$

$= n\ mg$ *(given)*

$\therefore$ $n = 0.5$

**28** As, $f_0 = \frac{v}{2l}$

Beat frequency $= f_1 - f_2$

$$= \frac{v}{2\left(\frac{l}{2}-\Delta l\right)} - \frac{v}{2\left(\frac{l}{2}+\Delta l\right)}$$

$$= (f_0 l)\left[\frac{2}{l-2\Delta l} - \frac{2}{l+2\Delta l}\right]$$

$$= 2f_0 l\left[\frac{4\Delta l}{l^2}\right] \approx \frac{8f_0\Delta l}{l}$$

$$= \frac{bf_0\Delta l}{l} \quad \text{(given)}$$

$\therefore$ $b = 8$

**29** Once the bricks leave the assistant's hands the only force that acts on them is gravitational force. Since this produces a constant acceleration $a = -g = -32$ fts$^{-2}$, the kinematic equation, $v^2 = v_0^2 - 2a(x - x_0)$, can be used to describe the motion. The initial velocity $v_0$ is found by putting known values in the above equation,

$v_0^2 = 36 + 2\times 32\times 10 = 676$

$\Rightarrow$ $v_0 = 26$ fts$^{-1}$

The kinetic energy given to each brick and supplied by the assistant is

$E_1 = \frac{1}{2}mv_0^2$

$= \frac{1}{2}\times m\times 676$

$= 338$ m ft$^2$s$^{-1}$

If the brick assistant supplied is only just enough energy to reach the required level and no more, the initial velocity being **u**, they would have zero velocity at the Mason's hand.

$\therefore u^2 = 0 + 2g(x - x_0)$

$= 2\times 32\times 10 = 640$

$\Rightarrow u = 8\sqrt{10}$ fts$^{-1}$

KE supplied in this case,

$E_2 = \frac{1}{2}mu^2 = 320$ m ft$^2$s$^{-2}$

$\therefore$ Wasted energy $= E_1 - E_2$

$$\%\text{ waste} = \frac{E_1 - E_2}{E_1}\times 100$$

$$= \frac{338-320}{320}\times 100$$

$= 5.6\%$

**30** Using conservation of angular momentum about the axis of cylinder for the (block + cylinder) system

$$mv_0R = mvR + \frac{MR^2\omega}{2}$$

$\Rightarrow$ $mv_0R = \frac{3}{2}mvR$

($\because v = \omega R$)

(when slipping stops)

$\Rightarrow$ $v = \frac{2v_0}{3}$

$= \frac{2v_0}{3}$ (given)

$\therefore$ $m = 3$