

NEET 2016 Phase 1 — Physics Question Paper with Solutions

38 Physics questions as set in the paper · answers checked by RankUp

NEET 2016 Phase 1 · Q1

1. From a disc of radius R and mass M , a circular hole of diameter R , whose rim passes through the centre is cut. What is the moment of inertia of the remaining part of the disc about a perpendicular axis, passing through the centre?

- (A) $15 MR^2/32$
- (B) $13 MR^2/32$
- (C) $11 MR^2/32$
- (D) $9 MR^2/32$

NEET 2016 Phase 1 · Q3

2. The magnetic susceptibility is negative for:

- (A) diamagnetic material only
- (B) paramagnetic material only
- (C) ferromagnetic material only
- (D) paramagnetic and ferromagnetic materials

NEET 2016 Phase 1 · Q4

3. A siren emitting a sound of frequency 800 Hz moves away from an observer towards a cliff at a speed of 15 ms^{-1} . Then, the frequency of sound that the observer hears in the echo reflected from the cliff is: (Take velocity of sound in air = 330 ms^{-1})

- (A) 765 Hz
- (B) 800 Hz
- (C) 838 Hz
- (D) 885 Hz

NEET 2016 Phase 1 · Q6

4. In a diffraction pattern due to a single slit of width ' a ', the first minimum is observed at an angle 30° when light of wavelength $5000 \text{ \AA}$ is incident on the slit. The first secondary maximum is observed at an angle of:

- (A) $\sin^{-1}(1/4)$
- (B) $\sin^{-1}(2/3)$
- (C) $\sin^{-1}(1/2)$
- (D) $\sin^{-1}(3/4)$

NEET 2016 Phase 1 · Q8

5. Out of the following options which one can be used to produce a propagating electromagnetic wave?

- (A) A charge moving at constant velocity
- (B) A stationary charge
- (C) A chargeless particle
- (D) An accelerating charge

NEET 2016 Phase 1 · Q9

6. Two identical charged spheres suspended from a common point by two massless strings of lengths l , are initially at a distance d ($d \ll l$) apart because of their mutual repulsion. The charges begin to leak from both the spheres at a constant rate. As a result, the spheres approach each other with a velocity v . Then v varies as a function of the distance x between the spheres, as:

- (A) $v \propto x^{(1/2)}$
- (B) $v \propto x$
- (C) $v \propto x^{(-1/2)}$
- (D) $v \propto x^{(-1)}$

NEET 2016 Phase 1 · Q10

7. A uniform rope of length L and mass m_1 hangs vertically from a rigid support. A block of mass m_2 is attached to the free end of the rope. A transverse pulse of wavelength λ_1 is produced at the lower end of the rope. The wavelength of the pulse when it reaches the top of the rope is λ_2 . The ratio λ_2/λ_1 is:

- (A) $\sqrt{(m_1/m_2)}$
- (B) $\sqrt{((m_1 + m_2)/m_2)}$
- (C) $\sqrt{(m_2/m_1)}$
- (D) $\sqrt{((m_1 + m_2)/m_1)}$

NEET 2016 Phase 1 · Q11

8. A refrigerator works between 4°C and 30°C . It is required to remove 600 calories of heat every second in order to keep the temperature of the refrigerated space constant. The power required is: (Take $1 \text{ cal} = 4.2 \text{ Joules}$)

- (A) 2.365 W
- (B) 23.65 W
- (C) 236.5 W
- (D) 2365 W

NEET 2016 Phase 1 · Q12

9. An air column, closed at one end and open at the other, resonates with a tuning fork when the smallest length of the column is 50 cm. The next larger length of the column resonating with the same tuning fork is:

- (A) 66.7 cm
- (B) 100 cm
- (C) 150 cm
- (D) 200 cm

NEET 2016 Phase 1 · Q14

10. The charge flowing through a resistance R varies with time t as $Q = at - bt^2$, where a and b are positive constants. The total heat produced in R is:

- (A) $a^3R/6b$
- (B) $a^3R/3b$
- (C) $a^3R/2b$
- (D) a^3R/b

NEET 2016 Phase 1 · Q15

11. A black body is at a temperature of 5760 K. The energy of radiation emitted by the body at wavelength 250 nm is U_1 , at wavelength 500 nm is U_2 and that at 1000 nm is U_3 . Wien's constant, $b = 2.88 \times 10^6 \text{ nmK}$. Which of the following is correct?

- (A) $U_1 = 0$
- (B) $U_3 = 0$
- (C) $U_1 > U_2$
- (D) $U_2 > U_1$

NEET 2016 Phase 1 · Q16

12. Coefficient of linear expansion of brass and steel rods are α_1 and α_2 . Lengths of brass and steel rods are l_1 and l_2 respectively. If $(l_2 - l_1)$ is maintained same at all temperatures, which one of the following relations holds good?

- (A) $\alpha_1 l_2 = \alpha_2 l_1$
- (B) $\alpha_1 l_2^2 = \alpha_2 l_1^2$
- (C) $\alpha_1^2 l_2 = \alpha_2^2 l_1$
- (D) $\alpha_1 l_1 = \alpha_2 l_2$

NEET 2016 Phase 1 · Q18

13. The intensity at the maximum in a Young's double slit experiment is I_0 . Distance between two slits is $d = 5\lambda$, where λ is the wavelength of light used in the experiment. What will be the intensity in front of one of the slits on the screen placed at a distance $D = 10 d$?

- (A) I_0
- (B) $I_0/4$
- (C) $3I_0/4$
- (D) $I_0/2$

NEET 2016 Phase 1 · Q19

14. A uniform circular disc of radius 50 cm at rest is free to turn about an axis which is perpendicular to its plane and passes through its centre. It is subjected to a torque which produces a constant angular acceleration of 2.0 rad s^{-2} . Its net acceleration in ms^{-2} at the end of 2.0 s is approximately:

- (A) 8.0
- (B) 7.0
- (C) 6.0
- (D) 3.0

NEET 2016 Phase 1 · Q20

15. An electron of mass m and a photon have same energy E . The ratio of de-Broglie wavelengths associated with them is: (c being velocity of light)

- (A) $(1/c)(E/2m)^{(1/2)}$
- (B) $(E/2m)^{(1/2)}$
- (C) $c(2mE)^{(1/2)}$
- (D) $(1/c)(2m/E)^{(1/2)}$

NEET 2016 Phase 1 · Q21

16. A disk and a sphere of same radius but different masses roll off on two inclined planes of the same altitude and length. Which one of the two objects gets to the bottom of the plane first?

- (A) Disk
- (B) Sphere
- (C) Both reach at the same time
- (D) Depends on their masses

NEET 2016 Phase 1 · Q22

17. The angle of incidence for a ray of light at a refracting surface of a prism is 45° . The angle of prism is 60° . If the ray suffers minimum deviation through the prism, the angle of minimum deviation and refractive index of the material of the prism respectively, are:

- (A) 45° ; $1/\sqrt{2}$
- (B) 30° ; $\sqrt{2}$
- (C) 45° ; $\sqrt{2}$
- (D) 30° ; $1/\sqrt{2}$

NEET 2016 Phase 1 · Q23

18. When an α -particle of mass ' m ' moving with velocity ' v ' bombards on a heavy nucleus of charge ' Ze ', its distance of closest approach from the nucleus depends on m as:

- (A) $1/m$
- (B) $1/\sqrt{m}$
- (C) $1/m^2$
- (D) m

NEET 2016 Phase 1 · Q24

19. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion?

- (A) 0.1 m/s^2
- (B) 0.15 m/s^2
- (C) 0.18 m/s^2
- (D) 0.2 m/s^2

NEET 2016 Phase 1 · Q25

20. The molecules of a given mass of a gas have r.m.s. velocity of 200 ms^{-1} at 27°C and $1.0 \times 10^5 \text{ Nm}^{-2}$ pressure. When the temperature and pressure of the gas are respectively, 127°C and $0.05 \times 10^5 \text{ Nm}^{-2}$, the r.m.s. velocity of its molecules in ms^{-1} is:

- (A) $100\sqrt{2}$
- (B) $400/\sqrt{3}$
- (C) $100\sqrt{2/3}$
- (D) $100/3$

NEET 2016 Phase 1 · Q26

21. A long straight wire of radius a carries a steady current I . The current is uniformly distributed over its cross-section. The ratio of the magnetic fields B and B' , at radial distances $a/2$ and $2a$ respectively, from the axis of the wire is:

- (A) $1/4$
- (B) $1/2$
- (C) 1
- (D) 4

NEET 2016 Phase 1 · Q27

22. A particle moves so that its position vector is given by $\vec{r} = \cos \omega t \hat{x} + \sin \omega t \hat{y}$, where ω is a constant. Which of the following is true?

- (A) Velocity and acceleration both are perpendicular to $\vec{r}$.
- (B) Velocity and acceleration both are parallel to $\vec{r}$.
- (C) Velocity is perpendicular to $\vec{r}$ and acceleration is directed towards the origin.
- (D) Velocity is perpendicular to $\vec{r}$ and acceleration is directed away from the origin.

NEET 2016 Phase 1 · Q28

23. What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop?

- (A) $\sqrt{gR}$
- (B) $\sqrt{2gR}$
- (C) $\sqrt{3gR}$
- (D) $\sqrt{5gR}$

NEET 2016 Phase 1 · Q29

24. When a metallic surface is illuminated with radiation of wavelength λ , the stopping potential is V . If the same surface is illuminated with radiation of wavelength 2λ , the stopping potential is $V/4$. The threshold wavelength for the metallic surface is:

- (A) 4λ
- (B) 5λ
- (C) $5\lambda/2$
- (D) 3λ

NEET 2016 Phase 1 · Q30

25. A gas is compressed isothermally to half its initial volume. The same gas is compressed separately through an adiabatic process until its volume is again reduced to half. Then:

- (A) Compressing the gas isothermally will require more work to be done.
- (B) Compressing the gas through adiabatic process will require more work to be done.
- (C) Compressing the gas isothermally or adiabatically will require the same amount of work.
- (D) Which of the case (whether compression through isothermal or through adiabatic process) requires more work will depend upon the atomicity of the gas.

NEET 2016 Phase 1 · Q31

26. A potentiometer wire is 100 cm long and a constant potential difference is maintained across it. Two cells are connected in series first to support one another and then in opposite direction. The balance points are obtained at 50 cm and 10 cm from the positive end of the wire in the two cases. The ratio of emf's is:

- (A) 5:1
- (B) 5:4
- (C) 3:4
- (D) 3:2

NEET 2016 Phase 1 · Q32

27. A astronomical telescope has objective and eyepiece of focal lengths 40 cm and 4 cm respectively. To view an object 200 cm away from the objective, the lenses must be separated by a distance:

- (A) 37.3 cm
- (B) 46.0 cm
- (C) 50.0 cm
- (D) 54.0 cm

NEET 2016 Phase 1 · Q33

28. Two non-mixing liquids of densities ρ and $n\rho$ ($n > 1$) are put in a container. The height of each liquid is h . A solid cylinder of length L and density d is put in this container. The cylinder floats with its axis vertical and length pL ($p < 1$) in the denser liquid. The density d is equal to:

- (A) $\{1 + (n + 1)\rho\}\rho$
- (B) $\{2 + (n + 1)\rho\}\rho$
- (C) $\{2 + (n - 1)\rho\}\rho$
- (D) $\{1 + (n - 1)\rho\}\rho$

NEET 2016 Phase 1 · Q35

29. A piece of ice falls from a height h so that it melts completely. Only one-quarter of the heat produced is absorbed by the ice and all energy of ice gets converted into heat during its fall. The value of h is: [Latent heat of ice is 3.4×10^5 J/kg and $g = 10$ N/kg]

- (A) 34 km
- (B) 544 km
- (C) 136 km
- (D) 68 km

NEET 2016 Phase 1 · Q36

30. The ratio of escape velocity at earth (v_e) to the escape velocity at a planet (v_p) whose radius and mean density are twice as that of earth is:

- (A) 1:2
- (B) $1:2\sqrt{2}$
- (C) 1:4
- (D) $1:\sqrt{2}$

NEET 2016 Phase 1 · Q37

31. If the magnitude of sum of two vectors is equal to the magnitude of difference of the two vectors, the angle between these vectors is:

- (A) 0°
- (B) 90°
- (C) 45°
- (D) 180°

NEET 2016 Phase 1 · Q38

32. Given the value of Rydberg constant is 10^7 m^{-1} , the wave number of the last line of the Balmer series in hydrogen spectrum will be:

- (A) $0.025 \times 10^4 \text{ m}^{-1}$
- (B) $0.5 \times 10^7 \text{ m}^{-1}$
- (C) $0.25 \times 10^7 \text{ m}^{-1}$
- (D) $2.5 \times 10^7 \text{ m}^{-1}$

NEET 2016 Phase 1 · Q39

33. A body of mass 1 kg begins to move under the action of a time dependent force $\mathbf{F} = (2t \hat{i} + 3t^2 \hat{j}) \text{ N}$, where $\hat{i}$ and $\hat{j}$ are unit vectors along x and y axis. What power will be developed by the force at the time t?

- (A) $(2t^2 + 3t^3) \text{ W}$
- (B) $(2t^2 + 4t^4) \text{ W}$
- (C) $(2t^3 + 3t^4) \text{ W}$
- (D) $(2t^3 + 3t^5) \text{ W}$

NEET 2016 Phase 1 · Q41

34. If the velocity of a particle is $\mathbf{v} = \mathbf{A}t + \mathbf{B}t^2$, where A and B are constants, then the distance travelled by it between 1s and 2s is:

- (A) $(3/2)A + 4B$
- (B) $3A + 7B$
- (C) $(3/2)A + (7/3)B$
- (D) $A/2 + B/3$

NEET 2016 Phase 1 · Q42

35. A long solenoid has 1000 turns. When a current of 4A flows through it, the magnetic flux linked with each turn of the solenoid is $4 \times 10^{-3} \text{ Wb}$. The self-inductance of the solenoid is:

- (A) 4 H
- (B) 3 H
- (C) 2 H
- (D) 1 H

NEET 2016 Phase 1 · Q43

36. A small signal voltage $V(t) = V_0 \sin \omega t$ is applied across an ideal capacitor C:

- (A) Current $I(t)$, lags voltage $V(t)$ by 90° .
- (B) Over a full cycle the capacitor C does not consume any energy from the voltage source.
- (C) Current $I(t)$ is in phase with voltage $V(t)$.
- (D) Current $I(t)$ leads voltage $V(t)$ by 180° .

37. Match the corresponding entries of column 1 with column 2. [Where m is the magnification produced by the mirror]

Column 1: (A) $m = -2$, (B) $m = -1/2$, (C) $m = +2$, (D) $m = +1/2$

Column 2: (a) Convex mirror, (b) Concave mirror, (c) Real image, (d) Virtual image

(A) $m = -2$: concave mirror, real image; $m = -1/2$: concave mirror, real image; $m = +2$: concave mirror, virtual image; $m = +1/2$: convex mirror, virtual image

(B) $m = -2$: convex mirror, real image; $m = -1/2$: convex mirror, virtual image; $m = +2$: convex mirror, concave mirror; $m = +1/2$: real image, virtual image

(C) $m = -2$: convex mirror, virtual image; $m = -1/2$: concave mirror, real image; $m = +2$: concave mirror, virtual image; $m = +1/2$: concave mirror, real image

(D) $m = -2$: real image, virtual image; $m = -1/2$: concave mirror, virtual image; $m = +2$: concave mirror, real image; $m = +1/2$: convex mirror, virtual image

38. A car is negotiating a curved road of radius R . The road is banked at an angle θ . The coefficient of friction between the tyres of the car and the road is μ_s . The maximum safe velocity on this road is:

- (A) $\sqrt{(gR^2 (\mu_s + \tan\theta))/(1 - \mu_s \tan\theta)}$
- (B) $\sqrt{(gR (\mu_s + \tan\theta))/(1 - \mu_s \tan\theta)}$
- (C) $\sqrt{((g/R) (\mu_s + \tan\theta))/(1 - \mu_s \tan\theta)}$
- (D) $\sqrt{((g/R^2) (\mu_s + \tan\theta))/(1 - \mu_s \tan\theta)}$

Answer key and explanations

1. Answer: (B) $13 MR^2/32$

The full disc has $I = MR^2/2 = 16MR^2/32$. The removed piece has mass $M/4$ and radius $R/2$, with its centre at $R/2$, so by the parallel axis theorem its $I = (M/4)(R/2)^2/2 + (M/4)(R/2)^2 = 3MR^2/32$. Remaining $I = 16MR^2/32 - 3MR^2/32 = 13MR^2/32$; forgetting the parallel-axis term gives the wrong $15MR^2/32$.

2. Answer: (A) diamagnetic material only

A diamagnetic material develops magnetisation opposite to the applied field, so its susceptibility is small and negative. Paramagnetic and ferromagnetic materials are magnetised along the field and have positive susceptibility.

3. Answer: (C) 838 Hz

The source approaches the cliff, so the cliff receives $f = 800 \times 330/(330 - 15) = 800 \times 330/315 \approx 838$ Hz. The stationary cliff reflects this frequency unchanged to the stationary observer, so the echo is heard at 838 Hz. 765 Hz is the frequency of the direct sound from the receding source, not the echo.

4. Answer: (D) $\sin^{-1}(3/4)$

First minimum: $a \sin 30^\circ = \lambda$, so $\lambda/a = 1/2$. The first secondary maximum lies at a $\sin\theta \approx 3\lambda/2$, giving $\sin\theta = 3/2 \times 1/2 = 3/4$. $\sin^{-1}(1/2)$ is the first minimum itself, not a maximum.

5. Answer: (D) An accelerating charge

Only an accelerating charge produces time-varying electric and magnetic fields that detach and propagate as an electromagnetic wave. A stationary charge gives only a static field and a uniformly moving charge gives a steady current-like field that does not radiate.

6. Answer: (C) $v \propto x^{(-1/2)}$

For small angles, equilibrium gives $kq^2/x^2 = mg \cdot (x/2l)$, so $q^2 \propto x^3$ and $q \propto x^{(3/2)}$. Differentiating, $dq/dt \propto x^{(1/2)} \cdot dx/dt$; since dq/dt is constant, $v = dx/dt \propto x^{(-1/2)}$. The speed therefore increases as the spheres come closer, ruling out $v \propto x^{(1/2)}$ and $v \propto x$.

7. Answer: (B) $\sqrt{((m_1 + m_2)/m_2)}$

Frequency stays the same, so $\lambda \propto v \propto \sqrt{T}$. Tension at the bottom is $m_2 g$ and at the top is $(m_1 + m_2)g$, so $\lambda_2/\lambda_1 = \sqrt{((m_1 + m_2)/m_2)}$. Putting m_1 in the denominator would wrongly use the rope's own weight as the bottom tension.

8. Answer: (C) 236.5 W

Coefficient of performance $= T_2/(T_1 - T_2) = 277/26 \approx 10.65$. Heat removed per second $= 600 \times 4.2 = 2520$ W, so power $= 2520/10.65 \approx 236.5$ W. Forgetting to convert calories to joules gives about 56 W, and slips in the powers of ten give the other values.

9. Answer: (C) 150 cm

For a closed pipe resonating with a fixed fork, resonant lengths are $\lambda/4, 3\lambda/4, 5\lambda/4, \dots$. The first is 50 cm, so the next is $3 \times 50 = 150$ cm. 100 cm would be the next length for a pipe open at both ends.

10. Answer: (A) $a^3R/6b$

Current $i = dQ/dt = a - 2bt$, which falls to zero at $t = a/2b$. Heat $H = \int_0^{a/2b} (a - 2bt)^2 R dt = R \cdot a^3/(6b)$. Forgetting to square the time-varying current (using an average current) gives the larger wrong values.

11. Answer: (D) $U_2 > U_1$

By Wien's law $\lambda_{\max} = b/T = 2.88 \times 10^6/5760 = 500$ nm, so emission peaks at 500 nm and U_2 is the largest; hence $U_2 > U_1$. A black body emits at all wavelengths, so neither U_1 nor U_3 is zero.

12. Answer: (D) $\alpha_1 l_1 = \alpha_2 l_2$

For the difference to stay constant, both rods must expand by the same amount for any temperature change: $l_1 \alpha_1 \Delta T = l_2 \alpha_2 \Delta T$, so $\alpha_1 l_1 = \alpha_2 l_2$. Swapping the lengths ($\alpha_1 l_2 = \alpha_2 l_1$) is the common trap.

13. Answer: (D) $l_0/2$

The point in front of a slit is at $y = d/2$, so path difference $= yd/D = (d/2)(d)/(10d) = d/20 = \lambda/4$, i.e. phase difference $\pi/2$. $I = I_0 \cos^2(\phi/2) = I_0 \cos^2(\pi/4) = I_0/2$. Using $I_0 \cos^2 \phi$ instead of $\cos^2(\phi/2)$ would wrongly give zero.

14. Answer: (A) 8.0

At $t = 2$ s, $\omega = \alpha t = 4$ rad/s. For a point on the rim, centripetal acceleration $= \omega^2 r = 16 \times 0.5 = 8$ m/s² and tangential acceleration $= \alpha r = 1$ m/s². Net $= \sqrt{64 + 1} \approx 8.06 \approx 8.0$ m/s²; taking only the tangential part misses the dominant centripetal term.

15. Answer: (A) $(1/c)(E/2m)^{1/2}$

For the electron $\lambda_e = h/\sqrt{2mE}$; for the photon $\lambda_p = hc/E$. Ratio $\lambda_e/\lambda_p = E/(c\sqrt{2mE}) = (1/c)\sqrt{E/2m}$. The expression without $1/c$ is not dimensionless, so it cannot be a ratio of wavelengths.

16. Answer: (B) Sphere

For rolling without slipping, acceleration $= g \sin \theta / (1 + k^2/R^2)$, independent of mass. A solid sphere has $k^2/R^2 = 2/5$, smaller than the disc's $1/2$, so the sphere accelerates more and reaches first. Mass does not matter because it cancels.

17. Answer: (B) $30^\circ; \sqrt{2}$

At minimum deviation $i = e$, so $\delta = 2i - A = 90^\circ - 60^\circ = 30^\circ$, and $r = A/2 = 30^\circ$. $\mu = \sin 45^\circ / \sin 30^\circ = \sqrt{2}$. A refractive index of $1/\sqrt{2}$ (less than 1) is impossible for a prism in air.

18. Answer: (A) $1/m$

At closest approach all kinetic energy becomes potential energy: $\frac{1}{2}mv^2 = k(Ze)(2e)/r_0$, so $r_0 = 4kZe^2/(mv^2)$. With v fixed, $r_0 \propto 1/m$: a heavier particle carries more kinetic energy and gets closer. A $1/\sqrt{m}$ or $1/m^2$ dependence does not follow from this energy balance.

19. Answer: (A) 0.1 m/s^2

$\frac{1}{2}mv^2 = 8 \times 10^{-4}$ J with $m = 0.01$ kg gives $v^2 = 0.16$ m²/s². The distance covered in two revolutions is $s = 2 \times 2\pi r = 4\pi \times 0.064 \approx 0.804$ m. From $v^2 = 2a_t s$, $a_t = 0.16/(2 \times 0.804) \approx 0.0995 \approx 0.1$ m/s²; 0.15 m/s² does not satisfy this.

20. Answer: (B) $400/\sqrt{3}$

$v_{\text{rms}} = \sqrt{3RT/M}$ depends only on temperature, not pressure. $v_2 = 200 \times \sqrt{(400/300)} = 200 \times 2/\sqrt{3} = 400/\sqrt{3}$ m/s. Scaling with pressure is the trap that leads to the smaller values.

21. Answer: (C) 1

Inside the wire $B = \mu_0 I r / (2\pi a^2)$, so at $a/2$, $B = \mu_0 I / (4\pi a)$. Outside $B' = \mu_0 I / (2\pi r)$, so at $2a$, $B' = \mu_0 I / (4\pi a)$. The ratio is 1. Treating the inside point as if all the current were enclosed (using $1/r$ there) would wrongly give a ratio of 4.

22. Answer: (C) Velocity is perpendicular to $\vec{r}$ and acceleration is directed towards the origin.

This is uniform circular motion of unit radius. $\vec{v} = \omega(-\sin \omega t \hat{x} + \cos \omega t \hat{y})$, and $\vec{v} \cdot \vec{r} = 0$, so velocity is perpendicular to $\vec{r}$. $\vec{a} = -\omega^2 \vec{r}$, so acceleration points towards the origin, not away from it.

23. Answer: (D) $\sqrt{5gR}$

At the top, the minimum speed is $\sqrt{gR}$ (tension or normal force zero). Energy conservation from bottom to top: $v^2 = gR + 2g(2R) = 5gR$, so $v = \sqrt{5gR}$. $\sqrt{gR}$ is the minimum speed at the top, not at entry.

24. Answer: (D) 3λ

$hc/\lambda - \phi = eV$ and $hc/2\lambda - \phi = eV/4$. Subtracting: $hc/2\lambda = 3eV/4$, so $eV = 2hc/3\lambda$, and $\phi = hc/\lambda - 2hc/3\lambda = hc/3\lambda$. Threshold wavelength $= hc/\phi = 3\lambda$.

25. Answer: (B) Compressing the gas through adiabatic process will require more work to be done.

On a P-V diagram the adiabatic curve is steeper, so during adiabatic compression the pressure rises faster and the area under the curve (work done on the gas) is larger for the same volume change. This holds for any $\gamma > 1$, so it does not depend on atomicity.

26. Answer: (D) 3:2

$(E_1 + E_2)/(E_1 - E_2) = 50/10 = 5$, so $E_1 + E_2 = 5E_1 - 5E_2$, giving $4E_1 = 6E_2$ and $E_1:E_2 = 3:2$. 5:1 is just the ratio of balancing lengths, not of the emfs.

27. Answer: (D) 54.0 cm

Objective: $1/v - 1/(-200) = 1/40$ gives $v = 50$ cm. For normal adjustment the image must be at the focus of the eyepiece, so separation $= 50 + 4 = 54$ cm. 44 cm ($f_o + f_e$) applies only to an object at infinity, and 50 cm ignores the eyepiece.

28. Answer: (D) $\{1 + (n - 1)p\}p$

Length pL is in the denser liquid and $(1 - p)L$ in the lighter one. Weight = buoyancy: $dL\Delta g = n\rho(pL)Ag + \rho(1 - p)L\Delta g$, so $d = \rho[1 + (n - 1)p]$. Using $(n + 1)$ comes from adding instead of subtracting the lighter-liquid share.

29. Answer: (C) 136 km

$(1/4)mgh = mL$, so $h = 4L/g = 4 \times 3.4 \times 10^5/10 = 1.36 \times 10^5$ m = 136 km. Ignoring the one-quarter factor gives 34 km.

30. Answer: (B) $1:2\sqrt{2}$

$v_e = \sqrt{(2GM/R)}$ and $M = (4/3)\pi R^3\rho$, so $v \propto R\sqrt{\rho}$. For the planet $v \propto 2R \times \sqrt{(2\rho)} = 2\sqrt{2}$ times earth's value. Hence $v_e:v_p = 1:2\sqrt{2}$; ignoring the density change gives 1:2.

31. Answer: (B) 90°

$|A + B|^2 = |A - B|^2$ gives $A^2 + B^2 + 2AB \cos\theta = A^2 + B^2 - 2AB \cos\theta$, so $\cos\theta = 0$ and $\theta = 90^\circ$. At 0° the sum would exceed the difference, and at 180° the difference would exceed the sum.

32. Answer: (C) $0.25 \times 10^7 \text{ m}^{-1}$

The last (series-limit) line of Balmer corresponds to $n = \infty \rightarrow 2$: wave number $= R(1/2^2 - 0) = 10^7/4 = 0.25 \times 10^7 \text{ m}^{-1}$. The first Balmer line would use $1/4 - 1/9$ instead.

33. Answer: (D) $(2t^3 + 3t^5) \text{ W}$

With $m = 1$ kg, $\vec{a} = F$, and starting from rest $\vec{v} = \int \vec{a} dt = t^2 \hat{i} + t^3 \hat{j}$. Power $P = F \cdot \vec{v} = 2t \cdot t^2 + 3t^2 \cdot t^3 = 2t^3 + 3t^5$ W. Multiplying force by time instead of integrating gives the wrong powers of t .

34. Answer: (C) $(3/2)A + (7/3)B$

Distance $= \int_1^2 (At + Bt^2) dt = A(2^2 - 1^2)/2 + B(2^3 - 1^3)/3 = (3/2)A + (7/3)B$ (the velocity does not change sign for positive A, B). $A/2 + B/3$ is the result of integrating from 0 to 1 instead.

35. Answer: (D) 1 H

Total flux linkage $N\Phi = LI$, so $L = N\Phi/I = 1000 \times 4 \times 10^{-3}/4 = 1$ H. Forgetting to divide by the current gives 4 H.

36. Answer: (B) Over a full cycle the capacitor C does not consume any energy from the voltage source.

In an ideal capacitor the current leads the voltage by 90° , so the power factor $\cos 90^\circ = 0$ and the average power over a full cycle is zero: energy stored in one quarter-cycle is returned in the next. Current lagging by 90° describes an ideal inductor, not a capacitor.

37. Answer: (A) $m = -2$: concave mirror, real image; $m = -1/2$: concave mirror, real image; $m = +2$: concave mirror, virtual image; $m = +1/2$: convex mirror, virtual image

A negative magnification means an inverted real image, which only a concave mirror forms, so $m = -2$ and $m = -1/2$ are both concave mirror with real image. $m = +2$ is an enlarged erect virtual image, possible only with a concave mirror, while $m = +1/2$ is a diminished erect virtual image, typical of a convex mirror. The matching that pairs a convex mirror with a real image is impossible.

38. Answer: (B) $\sqrt{(gR(\mu_s + \tan\theta))/(1 - \mu_s \tan\theta)}$

With friction acting down the incline at the maximum speed, resolving forces gives $v^2/(Rg) = (\sin\theta + \mu_s \cos\theta)/(\cos\theta - \mu_s \sin\theta) = (\mu_s + \tan\theta)/(1 - \mu_s \tan\theta)$. So $v_{\text{max}} = \sqrt{(gR(\mu_s + \tan\theta))/(1 - \mu_s \tan\theta)}$; only this form has units of velocity.

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