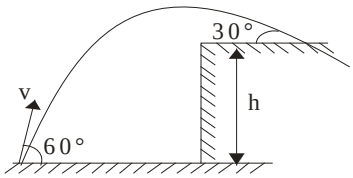
PART-A : PHYSICS

1. An unknown quantity 'α' is expressed as $\alpha = \frac{2ma}{\beta}\log\left(1+\frac{2\beta\ell}{ma}\right)$

where m = mass, a = acceleration, ℓ = length. The unit of α should be

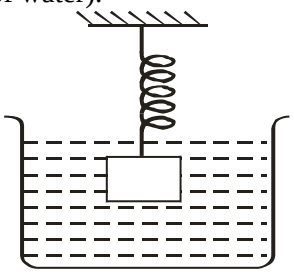
(A) meter (B) m/s (C) m/s^2 (D) N

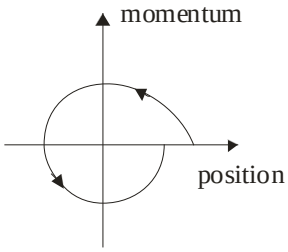
2. A stone projected at an angle of 60° from the ground level strikes at an angle of 30° on the roof of a building of height 'h'. Then the speed of projection of the stone is

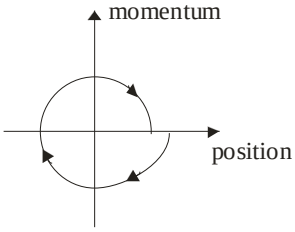


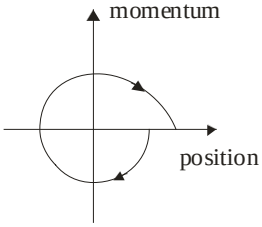
(A) $\sqrt{2gh}$ (B) $\sqrt{6gh}$ (C) $\sqrt{3gh}$ (D) $\sqrt{gh}$

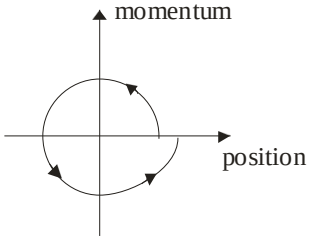
3. Consider the spring-mass system, with the mass submerged in water as shown in the figure. If mass is released with spring at natural length, then momentum-position diagram for one cycle of this system is (take down direction negative) (given density of mass is more than density of water).



(A) 

(B) 

(C) 

(D) 

4. A ball collides with a smooth and fixed inclined plane of inclination θ after falling vertically through a distance h. If it moves horizontally just after the impact, the coefficient of restitution is:

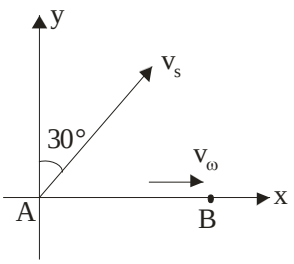
(A) $\tan^2\theta$ (B) $\cot^2\theta$ (C) $\tan\theta$ (D) $\cot\theta$

5. A solid uniform disc of mass m rolls without slipping down an inclined plane with an acceleration a. The frictional force on the disc due to surface of the plane is

(A) 2 ma (B) $\frac{3}{2}$ma (C) ma (D) $\frac{1}{2}$ma

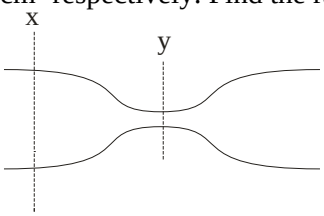
6. A wire of density 9 g/cc is stretched between two clamps 1 m apart while subjected to an extension of 0.05 cm. The lowest frequency of transverse vibrations in the wire is
(Assume Young's modulus Y = 9×10^{10} N/m^2)
(A) 35 Hz (B) 45 Hz (C) 75 Hz (D) 90 Hz

7. In the figure shown a source of sound of frequency 510 Hz moves with constant velocity v_s = 20 m/s in the direction shown. The wind is blowing at a constant velocity v_ω = 20 m/s towards an observer who is at rest at point B. The frequency detected by the observer corresponding to the sound emitted by the source at initial position A, will be (speed of sound relative to air = 330 m/s)



(A) 485 Hz (B) 500 Hz (C) 512 Hz (D) 525 Hz

8. Water flows in a horizontal tube as shown in figure. The pressure of water changes by 600 N/m^2 between x and y where the areas of cross section are 3 cm^2 and 1.5 cm^2 respectively. Find the rate of flow of water through the tube.



(A) 169 cm^3/s (B) 179 cm^3/s (C) 189 cm^3/s (D) 199 cm^3/s

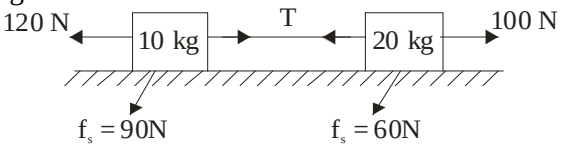
9. A uniform solid brass sphere is rotating with angular speed ω_0 about a diameter. If its temperature is now increased by 100°C. What will be its new angular speed?
(Given $\alpha_B = 2 \times 10^{-5}$/°C)

(A) $\frac{\omega_0}{1-0.002}$ (B) $\frac{\omega_0}{1+0.002}$ (C) $\frac{\omega_0}{1+0.004}$ (D) $\frac{\omega_0}{1-0.004}$

10. Block A of mass m is performing SHM of amplitude a. Another block B of mass m is gently placed on A when it passes through mean position and B sticks to A. Find the amplitude of new S.H.M.

(A) $\frac{a}{\sqrt{2}}$ (B) $\frac{a}{2}$ (C) $\frac{a}{2\sqrt{2}}$ (D) $a\sqrt{2}$

11. Find the tension T in the given diagram below.



Limiting friction between blocks and surface are also given in the figure.
(A) 30 N (B) 20 N (C) 40 N (D) 50 N

12. A diatomic gas is heated at constant pressure. If 105 J of heat is given to the gas, find the change in internal energy of the gas.
(A) 30 J (B) 35 J (C) 55 J (D) 75 J

13. Two hails stones with radii in the ratio of 1 : 2 fall from a great height through the atmosphere. Then the ratio of their momentum after they have attained terminal velocity is:
(A) 1 : 32 (B) 1 : 16 (C) 1 : 8 (D) 1 : 4

14. A solid sphere of radius R has a volume charge density $\rho = \rho_0 r^3$ (where ρ_0 is a constant and r is the distance from center). At a distance x from its centre (for x < R), the electric field is directly proportional to:
(A) x (B) x^2 (C) x^3 (D) x^4

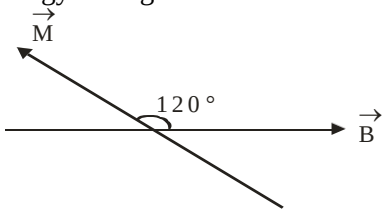
15. The force between two short dipoles separated by a distance r is directly proportional to
(A) r^2 (B) r^{-2} (C) r^{-3} (D) r^{-4}

16. A projectile is fired from the surface of earth of radius R with a speed kv_e in radially outward direction (where v_e is escape velocity and k < 1). Neglecting air resistance, the maximum height from the centre of the earth is:
(A) $\frac{R}{k^2+1}$ (B) $\frac{R}{1-k^2}$ (C) kR (D) k^2R

17. A coil has an inductance of $\frac{2.2}{\pi}$ H and is joined in series with a resistance of 220 Ω. When an alternating emf of 220V at 50 c.p.s. is applied to it, then the wattless component of the rms current in the circuit is
(A) 0.5 A (B) 0.7 A (C) 5 A (D) 7 A

18. A rod PQ of length ℓ is rotating with angular velocity ω about its mid-point, in a uniform magnetic field B which is perpendicular to the plane of rotation of the rod. Find the induced emf between PQ.
(A) $\frac{B\omega\ell^2}{2}$ (B) $\frac{B\omega\ell^2}{4}$ (C) $B\omega\ell^2$ (D) Zero

19. A magnet of magnetic dipole moment M is released in a uniform magnetic field of induction B from the position shown in the figure. Find its maximum kinetic energy during motion.



(A) $\frac{MB}{2}$ (B) MB (C) $\frac{3MB}{2}$ (D) 2MB

20. Resistance of a wire is 20 ohm, it is stretched upto three times of length, then its new resistance will be
(A) 6.67 Ω (B) 60 Ω (C) 120 Ω (D) 180 Ω

21. Light of wavelength 6000Å is incident normally on a single slit of width 24×10^{-5} cm. Find out the angular position of second minimum from central maxima?
(A) 15° (B) 30° (C) 45° (D) 60°

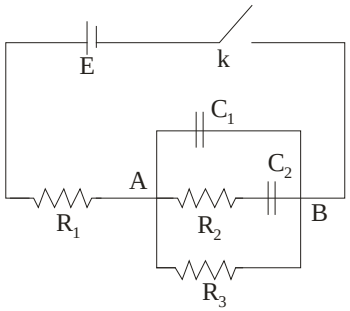
22. A plate of mass 10 gm is in equilibrium in air due to the force exerted by light beam on plate. Calculate power of the beam. Assume plate is perfectly absorbing.
(A) 3×10^7 W (B) 2×10^7 W (C) 3×10^5 W (D) 2×10^5 W

23. An electron beam of energy 10 KeV is incident on metallic foil. If the interatomic distance is 0.55Å. Find the angle of diffraction.
(A) $\sin^{-1}(0.11)$ (B) $\sin^{-1}(0.22)$ (C) $\cos^{-1}(0.11)$ (D) $\cos^{-1}(0.22)$

24. A plane EM wave of frequency 25 MHz travels in free space along the +x direction. At a particular point in space and time, $\vec{E} = 6.3\hat{j}$ V/m. What is $\vec{B}$ at this point?
(A) $2.52 \times 10^{-5}\ \hat{k}$T (B) $2.52 \times 10^{-5}(-\hat{k})$ T (C) $2.1\times10^{-8}\ \hat{k}$T (D) $2.1\times10^{-8}(-\hat{k})$T

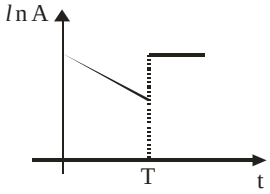
25. If a tuning fork of frequency (f_0) 340 Hz and tolerance $\pm 1\%$ is used in resonance column method, the first and the second resonance are measured at $\ell_1 = 24.0\text{cm}$ and $\ell_2 = 74.0\text{cm}$. Find maximum permissible error in speed of sound.
(A) 1% (B) 1.2% (C) 1.4% (D) 1.8%

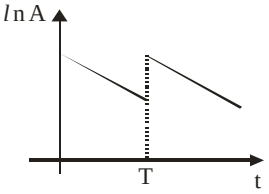
26. A network of uncharged capacitors and resistance is as shown. Current through the battery immediately after key k is closed and after a long time interval is

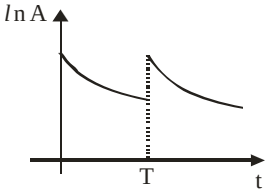


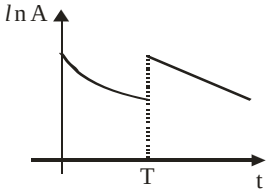
(A) $\frac{E}{R_1}, \frac{E}{R_1+R_3}$ (B) $\frac{E}{R_1+R_3}, \frac{E}{R_1+\frac{R_2R_3}{R_2+R_3}}$ (C) zero, $\frac{E}{R_1}$ (D) $\frac{E}{R_1+\frac{R_2R_3}{R_2+R_3}}, \frac{E}{R_1}$

27. At time t = 0, some radioactive gas is injected into a sealed vessel. At time T, some more of the same gas is injected into the same vessel. Which one of the following graphs best represents the variation of the logarithm of the activity A of the gas with time t?

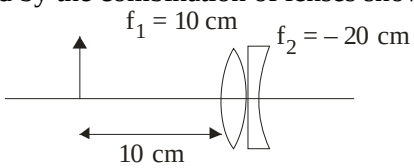
(A) 

(B) 

(C) 

(D) 

28. Find the laternal magnification produced by the combination of lenses shown in the figure.



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

29. A transistor is connected in common-emitter (C-E) configuration. The collector supply is 8V and the voltage drop across a resistor of 800 Ω in the collector circuit is 0.5V. If the current gain factor (α) is 0.96, find the base current.
(A) 24 μA (B) 25 μA (C) 26 μA (D) 28 μA

30. Find the binding energy of $^{56}_{26}Fe$. Atomic mass of ^{56}Fe is 55.9349 u and that of $^{1}_{1}H$ is 1.00783 u. mass of neutron = 1.00867 u.
(A) 462 MeV (B) 468 MeV (C) 472 MeV (D) 492 MeV