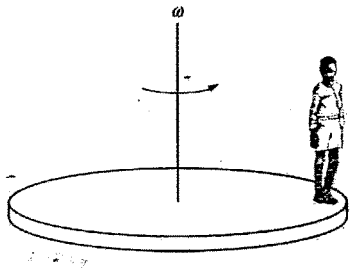
7. A child is standing on the edge of a rotating solid disk, as shown in the figure below.



The mass of the child is 40 kilograms. The disk has a mass of 200 kilograms and a radius of 2.5 meters, and it is rotating with an angular velocity of $\omega = 2.0$ radians per second. The child then walks slowly toward the center of disk. What will be the final angular velocity of the disk when the child reaches the center? (The size of the child can be neglected.)

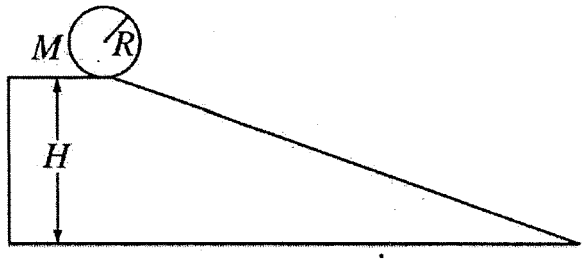
(A) 2.0 rad/s

(B) 2.2 rad/s

(C) 2.4 rad/s

(D) 2.8 rad/s

8. The cylinder shown below, with mass M and radius R, *has a radially dependent density.*



The cylinder starts from rest and rolls without slipping down an inclined plane of height H. At the bottom of the plane its translational speed is $(8gH/7)^{1/2}$. Which of the following is the rotational inertia of the cylinder?

(A) $\frac{1}{2}MR^2$

(B) $\frac{3}{4}MR^2$

(C) $\frac{7}{8}MR^2$

(D) MR^2

9. Two electrons are separated by 1 cm. The ratio of the gravitational force to the electrostatic force between the two electrons is approximately

(A) 10^{43}

(B) 10^{-43}

(C) 10^{36}

(D) 10^{-36}

10. A point particle of charge q is placed on the axis at a distance d from the centre of an insulated conducting sphere. The sphere has radius D and carries a total charge Q. If one of the image charges is $-(D/d)q$ and is located at a distance D^2/d from the centre of the sphere, then the other image charge and its location with respect to the centre of the sphere are, respectively,

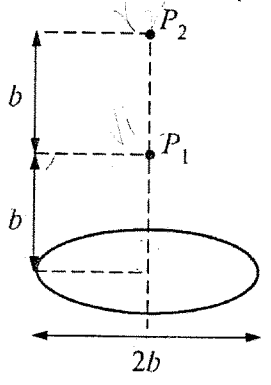
(A) $Q + (D/d)\ q\ ;\ 0$

(B) $Q + (D/d)\ q\ ;\ d^2/D$

(C) $Q + q\ ;\ 0$

(D) $Q - q\ ;\ 0$

11. A uniformly charged wire has the form of a circular loop with radius b. Consider two points on the axis of the loop. P_1 is at a distance b from the loop's center, and P_2 is at a distance $2b$ from the loop's center. (See the picture below)



The electrical potential V is zero very far from the loop. At P_1 and P_2 the potentials are V_1 and V_2 , respectively. What is V_2 in terms of V_1 ?

(A) $(1/3)\,V_1$

(B) $(2/5)\,V_1$

(C) $(1/2)\,V_1$

(D) $(\sqrt{2/5})\,V_1$

12. A proton and an electron are rotating in a plane in the presence of a uniform magnetic field of 1 tesla. What can you say about the sense of the rotation and their frequencies?

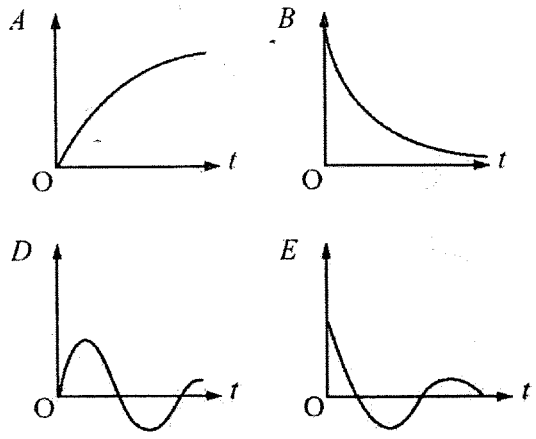
(A) Both rotate with the same sense and the electron rotates 1834 times faster

(B) Both rotate with the same sense and the electron rotates 1834 times slower

(C) They rotate in opposite directions and the electron rotates 1834 times faster

(D) They rotate in opposite directions and the electron rotates 1834 times slower

13. An electrical circuit contains an inductor and resistor connected in series with each other, a battery and a switch.



Select the graph that most nearly shows the nature of the time dependence of the voltage across the inductor in the circuit after the switch is thrown.

(A) A

(B) B

(C) D

(D) E

14. The secondary of an ideal step down transformer is connected to a 12 V (rms), 30 W bulb. If the primary is connected to 240 V (rms) mains power, the primary current (rms) is

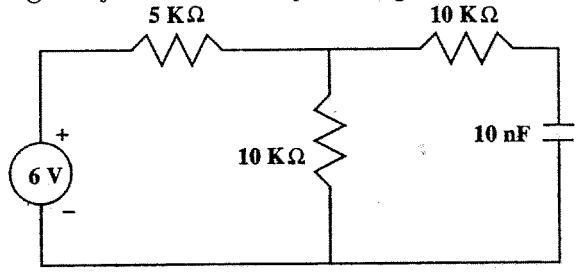
(A) 0.125 A

(B) 0.5 A

(C) 8 A

(D) 20 A

15. A capacitor is charged by a 6 V battery through the following circuit.



The final voltage across the capacitor is

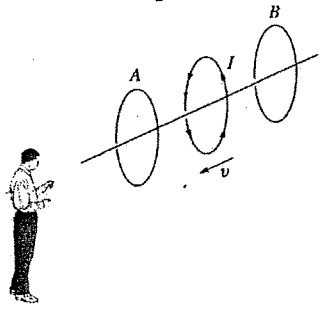
(A) 1 V

(B) 3 V

(C) 4 V

(D) 6 V

16. Three wire loops and an observer are positioned as shown in the figure below.



From the observer's point of view, a current I flows counterclockwise in the middle loop, which is moving towards the observer with a velocity u. Loops A and B are stationary. The observer would also notice that

(A) clockwise currents are induced in loops A and B

(B) counterclockwise currents are induced in loops A and B

(C) a clockwise current is induced in loop A, but a counterclockwise current is induced in loop B

(D) a counterclockwise current is induced in loop A, but a clockwise current is induced in loop B

17. A plane electromagnetic wave of intensity I_0 is incident normally at the planar interface separating two non-conducting and non-absorbing media having refractive indices n_1 and n_2, respectively. The reflectivity at the interface is given by $R = \left(\frac{n_1 - n_2}{n_1 + n_2}\right)^2$. The corresponding transmitted intensity is given by

(A) $\left(\frac{n_1 + n_2}{n_1 - n_2}\right) I_0$

(B) $\frac{n_2}{n_1}\left(\frac{2n_1}{n_1 + n_2}\right) I_0$

(C) $\frac{n_2}{n_1}\left(\frac{2n_1}{n_1 + n_2}\right)^2 I_0$

(D) $\left(\frac{2n_1}{n_1 + n_2}\right)^2 I_0$

18. For a plane-polarised electromagnetic wave the electric field vector is given by $\vec{E} = E_0 \exp[i(kx - \omega t)]\ \hat{j}$. The corresponding magnetic induction vector $\vec{B}$ is given by

(A) $\frac{E_0}{\omega} \exp[i(kx - \omega t)]\ \hat{k}$

(B) $E_0 \exp[i(kx - \omega t)]\ \hat{k}$

(C) $\frac{E_0}{c} \exp[i(kx - \omega t)]\ \hat{j}$

(D) $\frac{E_0}{c} \exp[i(kx - \omega t)]\ \hat{k}$

19. When unpolarised light is incident on a glass plate at a particular angle, it is observed that the reflected beam is linearly polarised. What is the angle of the refracted beam with respect to the surface normal? Refractive index of glass is 1.52

(A) 56.7°

(B) 33.4°

(C) 23.3°

(D) Light undergoes total-internal reflection and there is no refracted beam

20. A beam of light of wavelength $\lambda = 4.88 \times 10^{-5}$ cm falls normally onto a thin plate of quartz cut so that its optic axis lies in the surface. If $n_e = 1.553$ and $n_o = 1.544$, the thickness of the crystal which produces a phase difference of π between the ordinary and extra-ordinary rays is

(A) 0.0027 cm

(B) 1.544 cm

(C) 2.44 cm

(D) 2.7 cm

21. Unpolarized light of intensity I_0 is incident on a series of three polarizing filters. The axis of the second filter is oriented at 45° to that of the first filter, while the axis of the third filter is oriented at 90° to that of the first filter. What is the intensity of the light transmitted through the third filter?

(A) 0

(B) $I_0/8$

(C) $I_0/4$

(D) $I_0/2$

22. The speed of sound in an ideal gas changes if the temperature T of the gas changes. This speed is proportional to

(A) $T^{1/4}$

(B) $T^{1/2}$

(C) T

(D) T^2

23. An ideal diatomic gas is initially at temperature T and volume V. The gas is taken through three reversible processes in the following cycle: adiabatic expansion to the volume $2V$, constant volume process to the temperature T, isothermal compression to the original volume V. For the complete cycle described above, which of the following is true?

(A) Net thermal energy is transferred from the gas to the surroundings.

(B) The net work done by the gas on the surroundings is positive.

(C) The internal energy of the gas increases.

(D) The internal energy of the gas decreases.