PHYSICS

BOOKS - KVPY PREVIOUS YEAR

QUESTION PAPER 2020

Part I Physics

1. A mouse jumps off from the 15^{th} floor of a high-rise building and lands 12 m from the building. Assume that each floor is of 3m

height. The horizontal speed with which the mouse jumps is closest to :

A. 0

B. 5 kmph

C. 10 kmph

D. 15 kmph

Answer: D

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2. Consider two wires of same material having their ratio of radii to be 2 : 1. If these two wires are stretched by equal force, the ratio of stress produced in them is :

A. $\frac{1}{4}$

B. $\frac{1}{2}$

C. $\frac{3}{4}$

D. 1

Answer: A

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3. A submarine has a window of area $30 \times 30cm^2$ on its ceiling and is at a depth of 100m below sea level in a sea. If the pressure inside the submarine is maintained at the sea-level atmosphere pressure, then the force acting on the window is (consider density of sea water $= 1.03 \times 10^3 kg/m^3$, acceleration due to gravity $= 10m/s^2$

A. $0.93 \times 10^5 N$

B. $0.93 \times 10^3 N$

C. $1.86 \times 10^5 N$

D. $1.86 \times 10^3 N$

Answer: A

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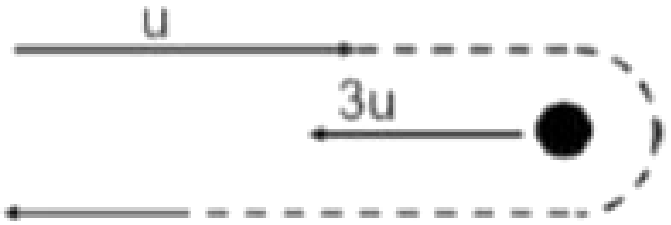
4. A spacecraft which is moving with a speed u relative to the earth in the x-direction, enters the gravitational field of a much more massive planet which is moving with a speed 3u in the negative x-direction. The spacecraft exits

following the trajectory as shown below.



The speed of the spacecraft with respect to the earth a long time after it has escaped the planet's gravity is given by

A. u

B. 4u

C. 2u

D. 7u

Answer: D

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5. The earth's magnetic field was flipped by 180° a million years ago. This flip was relatively rapid and took 10^5 years. Then the average change in orientation per year during the flip was closest to,

A. 1 second.

B. 5 seconds.

C. 10 seconds.

D. 30 seconds.

Answer: B

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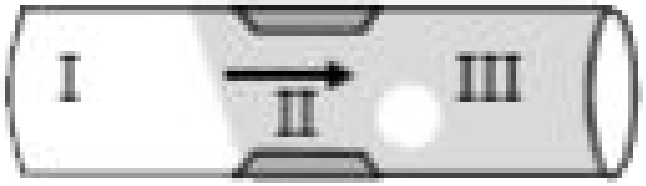
6. The platelets are drifting with the blood flowing in a streamline flow through a horizontal artery as shown below :



Artery is contracted in region II. Choose the correct statement.

A. As the platelets enter a constriction , the platelets gets squeezed closer together in the narrow region and hence the fluid pressure must rise there.

B. As the platelets enter a constriction , pressure is lower there.

C. The artery's cross section area is smaller in the constriction and thus the

pressure must be larger there because pressure equals the force divided by area

D. Pressure is same in all the parts of the artery

Answer: B

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7. Which is the following colourful patterns is due to diffraction of light?

A. Rainbow

B. White light dispersed using a prism

C. Colours observed on compact disc

D. Blue colour of sky

Answer: C

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8. Two balls are projected with the same velocity but with different angles with the horizontal. Their ranges are equal. If the angle of projection of one is 30^{o} and its maximum height is h, then the maximum height of other will be

A. 1h

B. 3h

C. 6h

D. 10h

Answer: B

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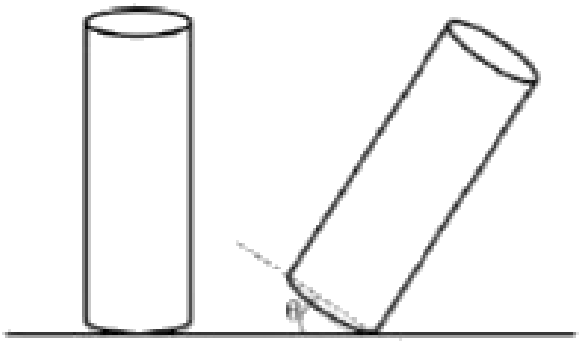
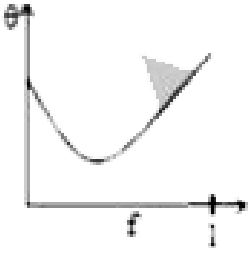
9. Figure below shows a shampoo bottle in a perfect cylindrical shape



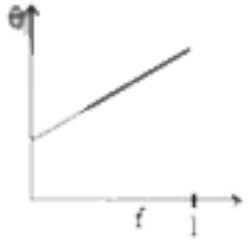
In a simple experiment, the stability of the bottle filled with different amount of shampoo

volume is observed. The bottle is tilted from one side and then released. Let the angle θ depicts the critical angular displacement resulting in the bottle losing its stability and tripping over. Choose the graph correctly depicting the fraction f of shampoo filled (f= 1 corresponds to completely filled) vs the tripping angle θ

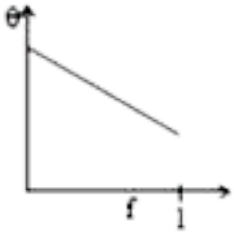
A.



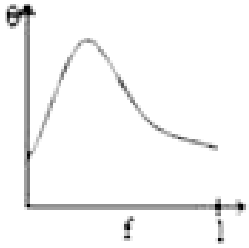
B.



C.



D.



Answer: D

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10. At a height of 10 km above the surface of earth, the value of acceleration due to gravity is the same as that of a particular depth below the surface of earth. Assuming uniform mass density of the earth, the depth is,

A. 1 km

B. 5 km

C. 10 km

D. 20 km

Answer: D

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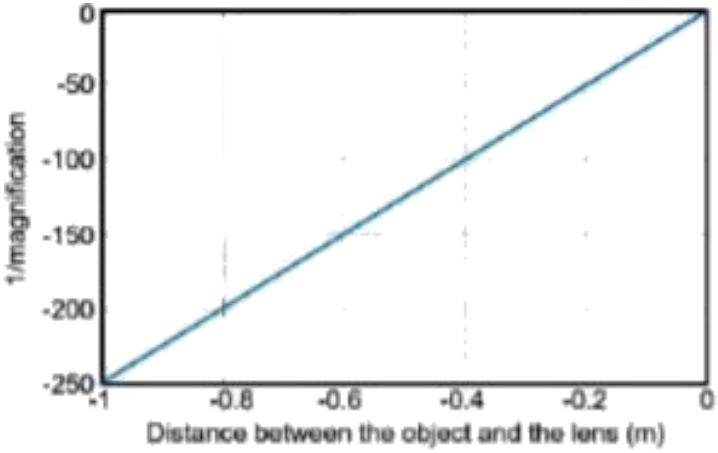
11. The following graph depicts the inverse of magnification versus the distance between the object and lens data for a setup. The focal length of the lens used in the setup is



A. 250 m

B. 0.004 m

C. 125 m

D. 0.002 m

Answer: B

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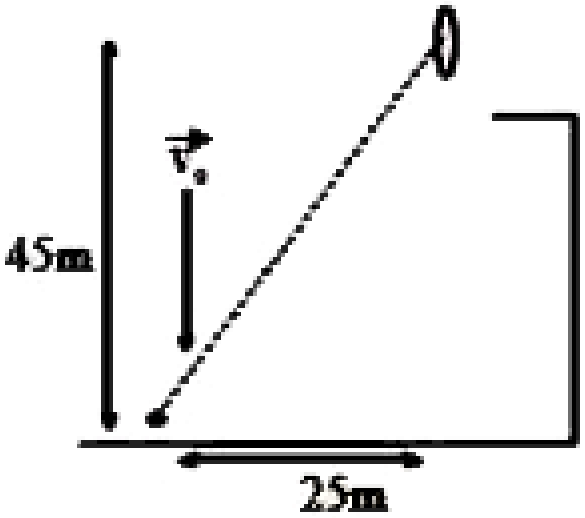
12. In a circus, a performer throws an apple towards a hoop held at 45 m height by another performer standing on a high platform (see figure below). The thrower aim s

for the hoop and throws the apple with a speed of 24 m/s.

At the exact moment that the thrower released the apple, the other performer drops the hoop.

The hoop falls straight down. At what height above the ground does the apple go through

the hoop ?



A. 21 m

B. 22 m

C. 23 m

D. 24 m

Answer: B

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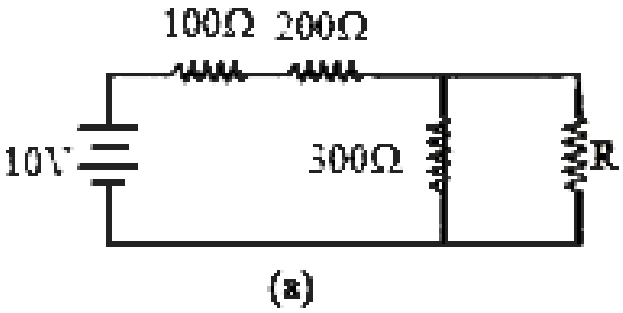
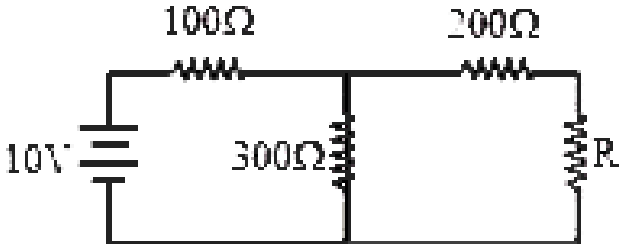
13. A student was trying to construct the circuit shown in the figure below maked (a), but ended up constructing the circuit marked (b). Realizing her mistake, she corrected the circuit , but to her surprise, the output voltage (across R) did not change.



(a)



(b)

The value of resistance R is :-

A. 100 Ω

B. 150Ω

C. 200Ω

D. 300Ω

Answer: A

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14. The ratio of gravitational force and electrostatic repulsive force between two electrons is approximately (gravitational constant $= 6.7 \times 10^{-11} Nm^2/kg^2$, mass of an

electron $= 9.1 \times 10^{-31} kg$, charge on an electron $= 1.6 \times 10^{-19} C$)

A. 24×10^{-24}

B. 24×10^{-36}

C. 24×10^{-44}

D. 24×10^{-54}

Answer: C

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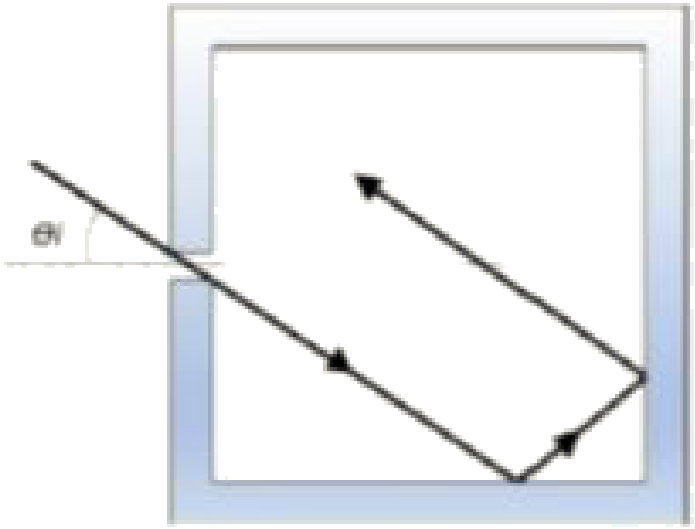
15. A monochromatic beam of light enters a square enclosure with mirrored interior surface at an angle of incidence $\theta I(\neq 0)$ (see the figure below). For some value (s) of θi, the beam is reflected by every mirrored wall (other than the one with the opening) exactly once and exits the enclosure through the same hole. which of the following statements about

this beam is correct?



A. The beam will not come out the enclosure for any value of θi.

B. The beam will not come out for more than two values of θi.

C. The beam will not come out only at $\theta i = 45^\circ$

D. The beam will come out for exactly two values of θi.

Answer: C

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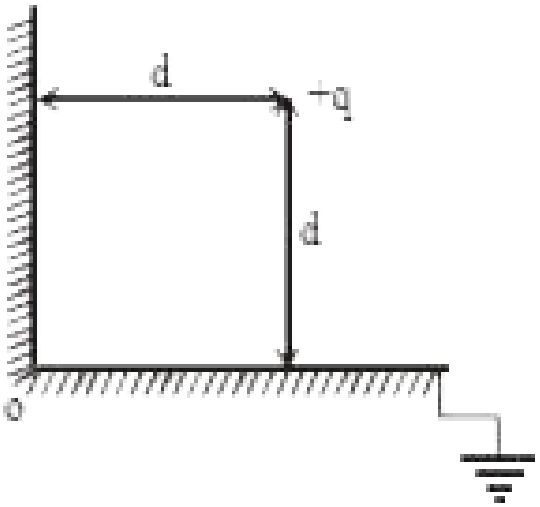
16. A charge +q is situated at a distance 'd' away from both the sides of a grounded conducting 'L' shaped sheet as shown in the

figure.



The force acting on the charge +q is

A. towards O, magnitude

$$\frac{q^2}{32\pi\varepsilon_0 d^2}\left(2\sqrt{2}+1\right)$$

B. away from O, magnitude

$$\frac{q^2}{32\pi\varepsilon_0 d^2}\left(2\sqrt{2}+1\right)$$

C. towards O, magnitude

$$\frac{q^2}{32\pi\varepsilon_0 d^2}(2\sqrt{2}-1)$$

D. away from O, magnitude

$$\frac{q^2}{32\pi\varepsilon_0 d^2}(2\sqrt{2}-1)$$

Answer: C

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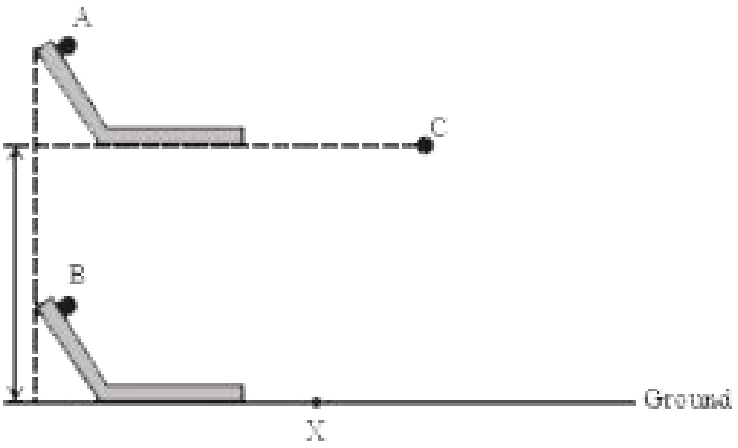
17. Three balls, A, B and C, are released and all reach the point X (shonw in the figure). Balls A and B are released from two identical

structures, one kept on the ground and the other at height, h, from the ground as shown in the figure. They time t_A and t_B respectively to reach X (time starts after they leave the end of the horizontal portion of the structure). The ball C is released from a point at height, h, vertically above X and reaches X in time t_C. Choose the correct statement.



A. $t_C < t_A < t_C$

B. $t_c = t_A = t_C$

C. $t_c = t_A < t_c$

D. $t_B < t_A = t_C$

Answer: B

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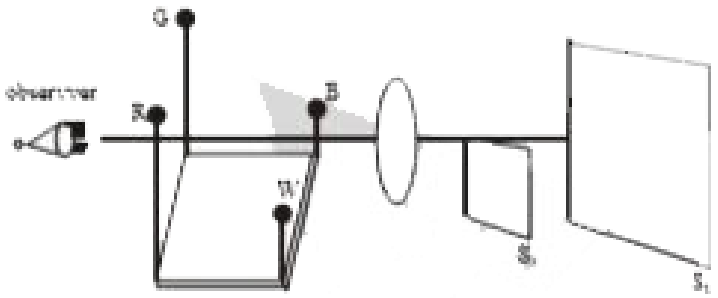
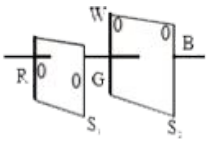
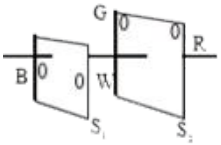
18. Four bulbs, red, green, white and blue (denoted by R, G, W and B respectively) are kept in front of a converging lens (as shown in

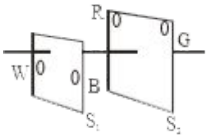
the figure below). The observer sees that the green and blue bulbs are kept to the left of the principle axis while the red and white bulbs are kept to the right of the principle axis. He also see that the red and green bulbs are above the principle axis while the white and blue bulbs are below the principle axis. The screens S_1 and S_2 are set at appropriate positions for the focusing to view the images.

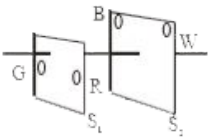


Choose the figure that correctly represents the images as seen by the observer.

A. 

B. 

C. 

D. 

Answer: A

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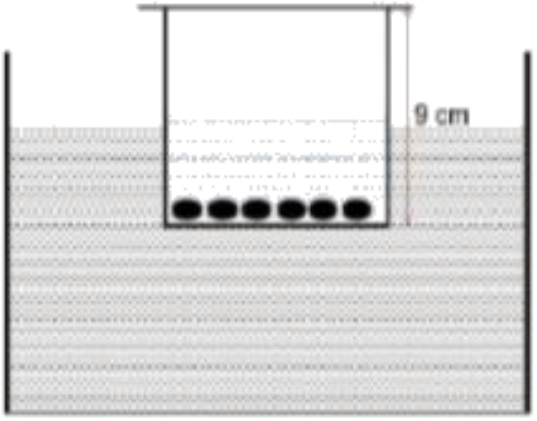
19. A wide bottom cylindrical massless plastic container of height 9 cm has 40 identical coins inside it and is floating on water with 3 cm inside the water. If we start putting more of such coins on its lid. It is observed that after N coins are put, its equilibrium changes from stable to unstable. Equilibrium in floating is stable if the geometric center of the submerged portion is above the center of

mass of the object) The value of N is closed to



A. 6

B. 10

C. 16

D. 24

Answer: B

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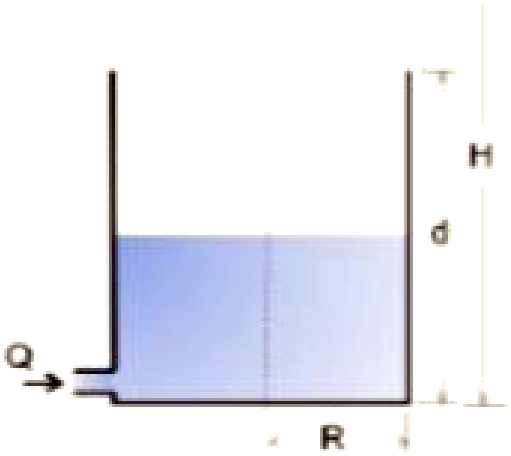
20. A small coin is fixed at the center of the base of an empty of cylindrical stell container having radius R = 1 m and height d = 4 m . At time t = 0 s, the container starts gettting filled with water at a flowrate of $Q = 0.1m^3/s$ without disturbing the coin . Find the approximate time when the coin will first be seen by teh observer "O" from the height of H= 5.75 m above and L = 1.5 m radially away from the coin as shown in the figure. Refractive

index of water in n = 1.33



A. 0 s

B. 32 s

C. 63 s

D. 150 s

Answer: C

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21. Students A, B and C measure the length of a room using 25 m long measuring tape of least count (LC) 0.5 cm, meter-scale of LC 0.1 cm and a foot-scale of LC 0.05 cm, respectively. If the specified length of the room is 9.5 m, then which of the following students will report the lowest relative error in the measured length ?

A. Student A

B. Student B

C. Student C

D. Both, student B and C

Answer: A

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22. Meena applies the front brakes while riding on her bicycle along a flat road. The force that slows her bicycle is provided by the

A. front tyre

B. road

C. rear tyre

D. brakes

Answer: B

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23. A proton and an antiproton come close to each other in vacuum such that the distance between them is 10 cm. Consider the potential

energy to be zero at infinity. The velocity at this distance will be

A. 1.17 m/s

B. 2.3 m/s

C. 3.0 m/s

D. 23 m/s

Answer: A

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24. A point particle is acted upon by a restoring force –kx3 . The time period of oscillation is T when the amplitude is A. The time period for an amplitude 2A will be :

A. T

B. $T/2$

C. $2T$

D. $4T$

Answer: B

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25. The output voltage (taken across the resistance) of a LCR series resonant circuit falls to half is peak value at a frequency of 200 Hz and again reaches the same value at 800 Hz. The bandwidth of this circuit is

A. 200 Hz

B. $200\sqrt{3}Hz$

C. $400Hz$

D. $600Hz$

Answer: B

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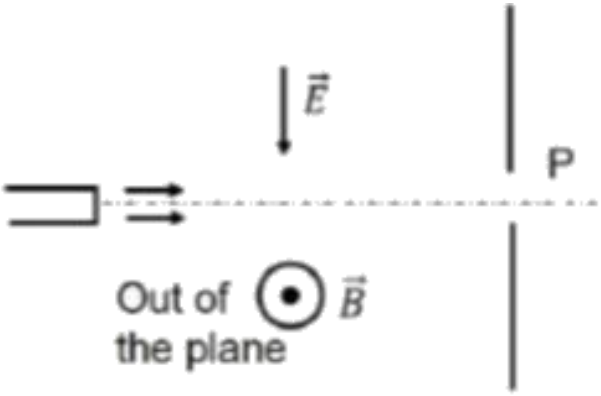
26. A collimated beam of charged and uncharged particles is directed towards a hole marked P on a screen as shown below. If the electric and magnetic fields as indicated below

are turned on.



A. only particles with speed E/B will go through the hole P

B. only charged particles with speed E/B and neutral particles will go through P

C. only neutral particles will go through P.

D. only positively charged particles with speed E/B and neutral particles will go through P

Answer: C

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27. An engine runs between a reservoir at temperature 200 K and a hot body which is initially at temperature of 600 K. If the hot body cools down to a temperature of 400 K in

the process, then the maximum amount of work that the engine can do (while working in a cycle) is (the heat capacity of the hot body is 1 J/K)

A. $200(1 - \ln 2)$ J

B. $200(1 - \ln 3/2)$ J

C. $200(1 + \ln 3/2)$ J

D. 200 J

Answer: B

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28. The clocktower ("ghantaghar") of Dehradun is famous for the sound of its bell, which can be heard, albeit faintly, upto the outskirts of the city 8 km away. Let the intensity of this faint sound be 30 dB. The clock is situated 80 m high. The intensity at the base of the tower is :-

A. 60 dB.

B. 70 dB.

C. 80 dB

D. 90 dB

Answer: B

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29. An initially uncharged capacitor C is being charged by a battery of emf E through a resistance R upto the instant when the capacitor is charged to the potential E/2, the ratio of the work done by the battery to the heat dissipated by the resistor is given by :-

A. $2:1$

B. $3:1$

C. $4:3$

D. $4:1$

Answer: C

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30. Consider a sphere of radius R with unform charged density and total charge Q. The electrostatic potential distribution inside the

sphere is given by $\phi(r) = \frac{Q}{4\pi\varepsilon_0 R}\left(a + b(r/R)^c\right)$ Note that the zero of potential is at infinity. The values of (a, b, c) are :-

A. $\left(\frac{1}{2}, -\frac{3}{2}, 1\right)$

B. $\left(\frac{3}{2}, -\frac{1}{2}, 2\right)$

C. $\left(\frac{1}{2}, \frac{1}{2}, 1\right)$

D. $\left(\frac{1}{2}, -\frac{1}{2}, 2\right)$

Answer: B

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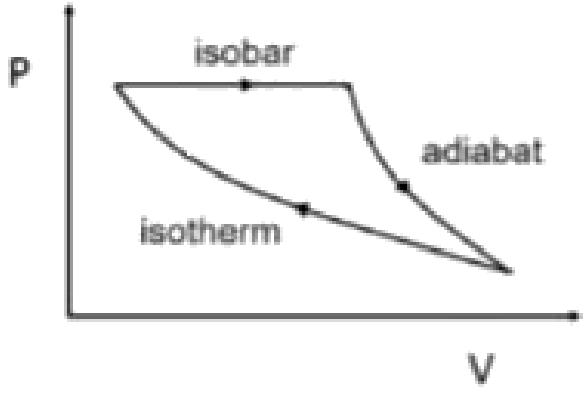
31. The efficiency of the cycle shown below in the figure (consisting of one isobar , one adiabatic and one isotherm (is 50 % the ratio ,x, between the highest and lowest temperature attained in this cycle obeys (the working substance is an ideal gas)



A. $x = e^{x-1}$

B. $x^2 = e^{x-1}$

C. $x = e^{x^2-1}$

D. $x^2 = e^{x^2-1}$

Answer: B

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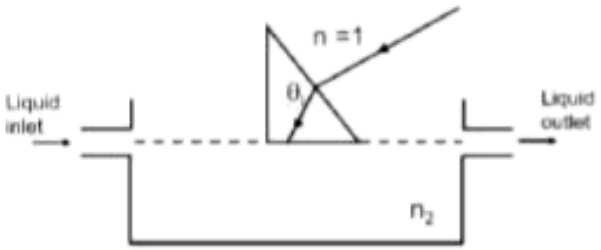
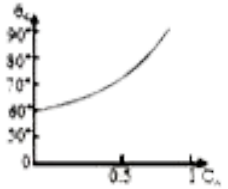
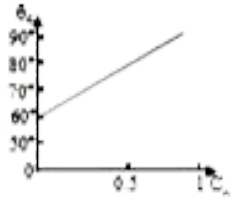
32. A right - angled isoceles prism is held on the surface of a liquid composed of miscible solvents A and B of refractive index

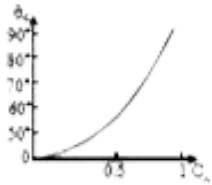
$n_A = 1.50$ and $n_B = 1.30$ respectively . The refractive index of prism is $n_p = 1.5$ and that of the liquid is given by $N_L = C_A n_A + (1 - C_A) n_B$ where C_A is the percentage of solventA in the liquid

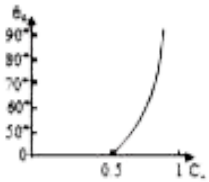


IF θ_C is the critical angle at prism - liquid interface . the plot which best represents the variation of the critical angle with the percentage of solvent is

A. 

B. 

C. 

D. 

Answer: A

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33. Instead of angular momentum quantization a student posits that energy is quantized as $E = -E_0/n(E_0 > 0)$ and n is a positive interger . Which of the following options is correct ?

A. The radius of the electron orbit is

$r \propto \sqrt{n}$

B. The speed of the electron is $v \propto \sqrt{n}$

C. The angular speed of the electron is

$$\omega \propto 1/n$$

D. The angular momentum of the electron is $\propto \sqrt{n}$

Answer: D

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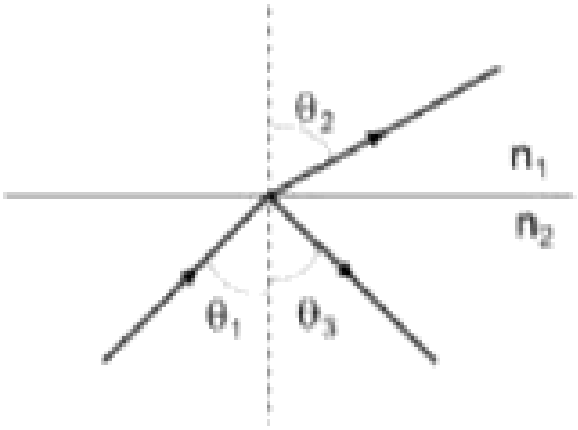
34. A monochromatic beam of light is incident at the interface of two materials of refractive index n_1 and n_2 as shown . If $n_1 > n_2$ and θ_C

is the critical angle then which of the following statements is NOT true ?



A. $\theta_1 = \theta_3$ for all value of θ_1

B. $\cos\theta_2$ is imagimary for $\theta_1 > \theta_c$

C. $\cos\theta_2 = 0$ for $\theta_1 = \theta_c$

D. $\cos\theta_3$ is imaginary for $\theta_1 = \theta_c$

Answer: D

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35. The intensity of light from a continuously emitting laser source operating at 638 nm wavelength is modulated at 1 GHz . The modulation is done by momentarily cutting the intensity off with a frequency of 1 GHz . What is the farthest distance apart two detectors can be placed in the line of the laser light so that they can see the portions of the

same pulse simultaneously ? (consider the speed of light in air $3 \times 10^8 m/s$)

A. 30μ m

B. $30cm$

C. $3m$

D. $30m$

Answer: B

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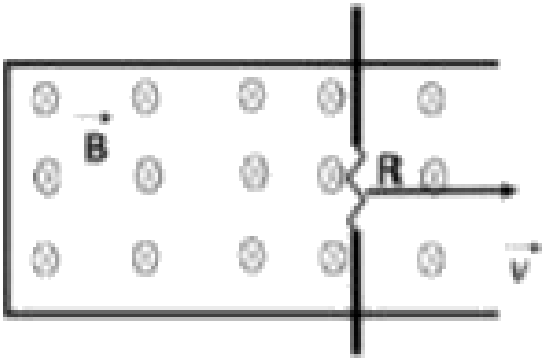
36. A conducting rod, with a resistor of resistance R. is pulled with constant speed v on a smooth conducting rail as shown in figure. A constant magnetic field $\overrightarrow{B}$ is directed into the page. If the speed of the bar is doubled, by what factor does the rate of heat dissipation across the resistance R change?



A. 0

B. $\sqrt{2}$

C. 2

D. 4

Answer: D

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37. The time period of a body undergoing simple harmonic motion is given by $T = p^a D^b S^c$, where p is the pressure, D is

density and S is surface tension. The values of a, b and c respectively are

A. $1, \frac{1}{2}, \frac{3}{2}$

B. $\frac{3}{2}, -\frac{1}{2}, 1$

C. $1, -\frac{1}{2}, \frac{3}{2}$

D. $-\frac{3}{2}, \frac{1}{2}, 1$

Answer: D

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38. Consider the following statements regarding the real images formed with a converging lens. I -Real images can be seen only if the image is projected onto the screen . (2)The real image can be seen only from the same side of the lens as that on which the object is positioned. (3)Real images produced by converging lenses are not only laterally but also longitudinally inverted as with mirrors. Which of the above statement/statements is/are incorrect?

A. Only I and III

B. All three

C. None

D. only II

Answer: B

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39. A zinc ball of radius, R=1 cm charged to a potential -0.5 V. The ball is illuminated by a monochromatic ultraviolet (UV) light with a

wavelength 290 nm. The photoelectric threshold for zinc is 332 nm. The potential of ball after a prolonged exposure to the UV is

A. $-0.5v$

B. $0v$

C. $0.54v$

D. $0.79v$

Answer: C

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40. A source simultaneously emitting light at two wavelengths 400 nm and 800 nm is used in the Young's double slit experiment. If the intensity of light at the slit for each wavelength is I_0, then the maximum intensity that can be observed at any point on the screen is

A. I_0

B. $2I_0$

C. $4I_0$

D. $8I_0$

Answer: D

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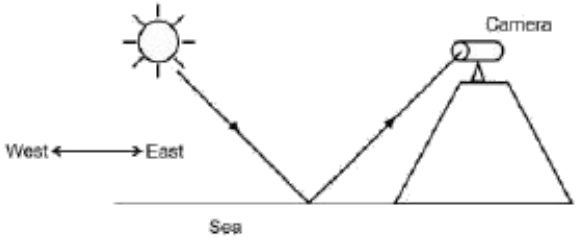
41. A camera filled with a polarizer is placed on a mountain in a manner to record only the reflected image of the sun from the surface of a shown in the figure. If the sun rise at 6.00 AM and sets at 6.00 PM during the summer, then at what time in the aftermoon will the recorded image have the lowest intensity, assuming there are no clouds and intensity of

the sun at the sea surface is constant throughout the day?



A. $12.32PM$

B. $3.32PM$

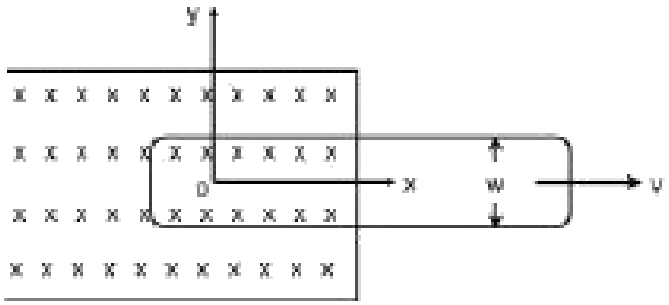
C. $5.00PM$

D. $6.00PM$

Answer: B

Watch Video Solution

42. Suppose a long rectangular loop of width w is moving along the x-direction with its left arm in a magnetic field perpendicular to the plane of the loop (see figure). The resistance of the loop is zero and it has an inductance L. At time t = 0, its left arm passes the origin O.

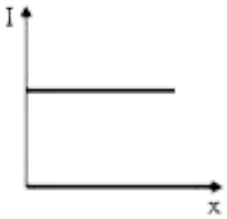


If for $t \geq 0$ the current in the loop is I and the

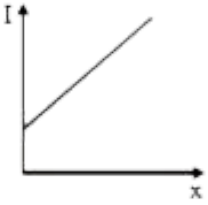
distance of its left are arm from the origin is x

then I versus x graph will be

A.

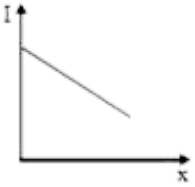


B.



C.

D.



Answer: B

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43. Imagine a would where free magnetic charges exist. In this world, a circuit is made with a U shape wire and a rod free to slide on it. A current carried by free magnetic charges can flow in the circuit. When the circuit is placed in a uniform electric field. E perpendicular to the plane of the plane of the circuit and the rod is pulled to the right with a

constant speed v, the "magnetic EMF" in the current and the direction of the corresponding current. arising because of changing electric flux will be (l is the length of the rod and c is the speed of light).

A. vEl clockwise

B. vEL counterclockwise

C. $\frac{vEl}{c^2}$ clockwise

D. $\frac{vEl}{c^2}$ counterclockwise

Answer: D

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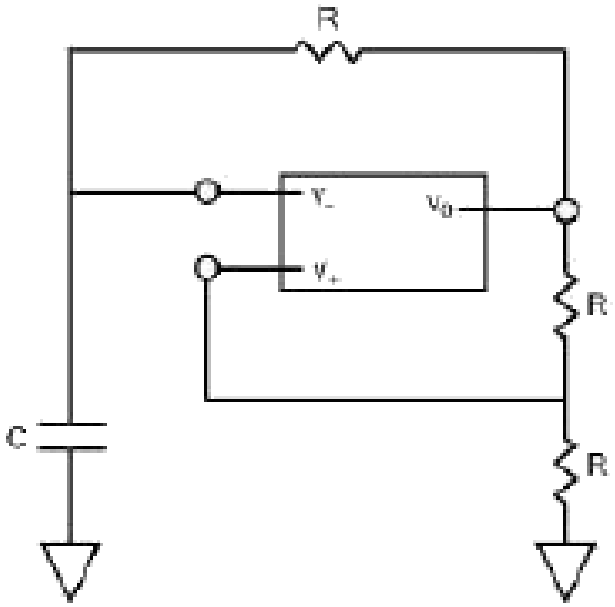
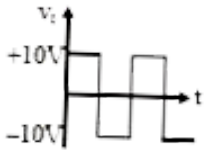
44. The box in the circuit below has two inputs marked $v+$ and $v-$ and a single output marked V_o. The output obeys

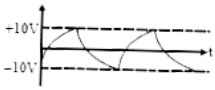
$+10V$ if $v+ > v-$

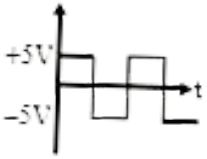
$V_0 = -10V$ if $v+ < v-$



The output V_0 of this circuit a long time after is switched on is best represented by

A. 

B. 

C. 

D. 

Answer: A

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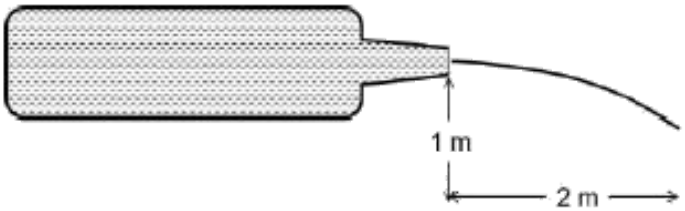
45. A bottle has a thin nozzle on top. It is filled with water, held horizontally at a height of 1 m and squeezed slowly by hands so that the water jet coming out of the nozzle hits the

ground at a distance of 2m . If the area over which the hands squeeze it is $10cm^2$. the force applied by hand is close to (take g= 10 m/s^2 and density of water= 1000 kg/m^3)



A. $20N$

B. $10N$

C. $5N$

D. $2.5N$

Answer: B

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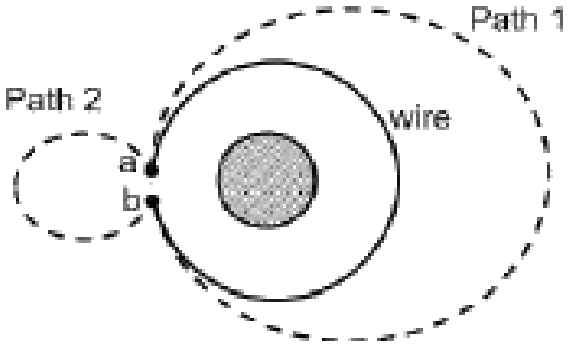
46. The circular wire in figure below encircles solenoid in which the magnetic flux is increasing at a constant rate out of the plane of the page.



The clockwise emf around the circular loop is $\varepsilon 0$. By definition a voltammeter measures the volatage difference between the two pointws given by $V_b - V_a = -\int_a^b \overline{E}.\, d\bar{s}$. We assume that a and b are infinitestically close to each other. The values of $V_b - V_a$ alon the path 1 and $V_a - V_b$ along the path 2, respectively are

A. $-\varepsilon_0,\ -\varepsilon_0$

B. $-\varepsilon_0, 0$

C. $-\varepsilon_0, \varepsilon_0$

D. $\varepsilon_0, \varepsilon_0$

Answer: B

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47. A beam of neutrons performs circular motion of radius, r = 1 m, under the influence of an inhomogeneous magnetic field with inhomogeneity extending over $\Delta r = 0.01$ m. The speed of the neutrons is 54 m/s. The mass and magnetic moment of the neutrons respectively are $1.67 \times 10^{-27} kg$ and $9.67x \times 10^{-27}$ J/T. The

average variation of the magnetic field over Dr is approximately.

A. $0.5T$

B. $1.0T$

C. $5.0T$

D. $10.0T$

Answer: C

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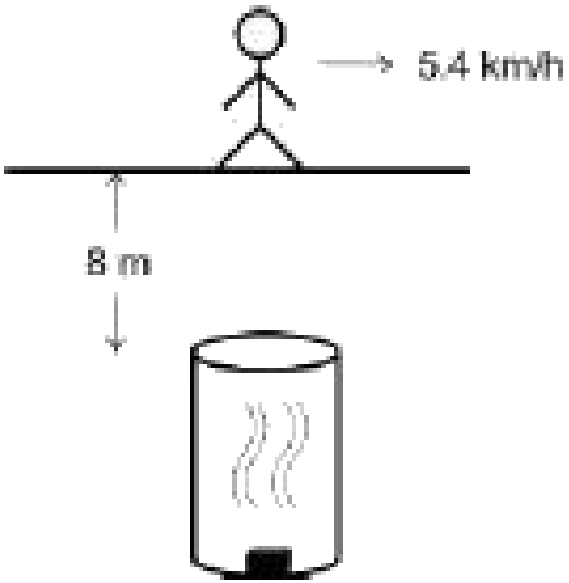
48. A student is jogging on a straight path with the speed 5.4 km per hour. Perpendicular to the path is kept a pipe with its opening 8m from the road (see figure). Diameter of the pipe is 0.45 m . At the other end of the pipe is a speaker emitting sound of 1280 Hx to wards the opening of the pipes. As the student passes in front of the pipe, she hears the speaker for T seconds. T is in the range (Take

speed of sound, 320 m/s)



A. $6 - 12$

B. $12 - 18$

C. $3 - 6$

D. $18 - 22$

Answer: A

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49. A solar cell is to be fabricated for efficient conversion of solar radiation to emf using material A. The solar cell is to be mechanically protected with the help of a coating using material B. If the band gap energy of materials A and B are E_A and E_B respectively, then which of the following choices is optimum for better performance of the solar cell.

A. $E_A = 1.5eV, E_B = 5eV$

B. $E_A = 1.5eV, E_B = 1.5eV$

C. $E_A = 3eV, E_B = 1.5eV$

D. $E_A = 0.5eV, E_B = 5eV$

Answer: A

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50. The "Kangi" is and earthen pot used to stay warm in Kashmir during the winter monts. Assume that the " Kangri" is shericla

and of surface are $7 \times 10^{10-2} m^2$. It contains 300 g of mixture of coal. Wood and leaves with calorific value of 30 kj/g (and provides heat with 10 % efficiency.) The surface temperature of the "Kangri" is $60^\circ C$ and the room temperature is $0^\circ C$. Then, a reasonable estime for the duration t(in hours) that the "kangri" heat will last is (take the "kangri" to be a black body).

A. 8

B. 10

C. 12

D. 16

Answer: B

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