### PHYSICS

 Two lens each of focal length 20 cm, one is covering and one is diverging are placed as shown. What will be overall magnification.



A sample Q has half life 20 min. It decays by emitting alpha particle and Beta particle with probability of 60% and 40% respectively.
 Initially sample of Q contains 1000 particles then number of α-particle after 1 hours will be

**Sol.** To the no. of half life =3 No. of  $(\alpha + \beta)$  emitted in 3 half life =  $\frac{7No}{8} = \frac{7000}{8}$ 

out of it no of  $\alpha$  particle =  $\frac{60}{100} \times \frac{7000}{8} = \frac{4200}{8} = 525$ 





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4. In a vernier caliper, zero of vernier scale lies left to zero of main scale.



 $6^{th}$  division of vernier scale coincides with main scale when diameter of a cylinder is measured. Zero of vernier scale is ahead of 3.1 cm marked and  $1^{st}$  division of vernier scale matches with main scale.

Given : 9 MSD = 10 VSD

Least count of main scale is 0.1 cm.

(A) 3.15 cm (B) 3.06 cm (C) 3.11 cm (D) 3.18 cm

Ans. (A)

**Sol.** So LC = 1 MSD - 1 VSD

$$= 0.1 - \frac{9}{10}$$
 MSD = 0.01 cm

When there is no object

Zero error = -0.04 cm

When object  $D = 3.1 + 1 \times 0.01 = 3.11$  cm

Reading of object = 3.11 + 0.04 = 3.15cm

Comprehension (Q.5 and 6)

5. Particle is projected with speed  $5\sqrt{2}$  m/s at an angle of projection  $45^{\circ}$  from horizontal. At maximum height it breaks in two identical particle, velocity of one particle is zero, find out distance of second particle from point of projection when its hits ground.

Sol. Using position of COM

$$r_{CM} = \frac{m_1 r_1 + m_2 r_2}{m_1 + m_2} \implies R = \frac{\frac{m}{2} \times \frac{R}{2} + \frac{m}{2} \times x}{m}$$

$$R = \frac{R}{4} + \frac{x}{2}$$

$$\frac{3R}{4} = \frac{x}{2}$$

$$x = \frac{3R}{2} = \frac{3}{2} \times \frac{u^2 \sin 2\theta}{g} = \frac{3}{2} \times \frac{50 \times 1}{10} = 7.5m$$

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## Image: Second State S

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6. Find time (in sec) when first part strikes the ground after explosion. Ans. 0.5

Sol. 
$$H = \frac{(5\sqrt{2})^2 \sin^2 4s}{2g} = \frac{50 \times 1}{20 \times 2} = \frac{50}{40} = \frac{5}{4}m$$
  
 $T = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 5/4}{10}} = \frac{1}{\sqrt{4}} = 0.5 \sec$   
Ans. 0.5

7.





In above figure switch S is connected at position P for a long time. If charge on capacitor at steady state is X then find the value of X (in  $\mu$ C).

Ans. 1.33



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8. Long after switch is connected to P it is shifted on position Q if charge on capacitor long after that instant is  $Y\mu C$ . Then find the value of Y.

Ans. 0.67

Sol.



at steady state current through capacitor = 0

$$I = \frac{2}{3}Amp$$

Potential difference across capacitor

= Potential difference across  $1\Omega$  resistor

$$V_{\rm A} - V_{\rm B} = I(1) = \frac{2}{3}V$$

Charge on Capacitor =  $y = C(V_A - V_B)$ 

$$= 1 \times \frac{2}{3} \mu F = 0.67 \ \mu F$$

Comprehension (Q. 9 and 10)

O)



There is a equipotential circle in xy-plane with potential V = 0



Find out radius of circle (in meter) 9.

 $\sqrt{3}$ Ans.

10. Distance of centre of circle from 
$$\frac{Q}{\sqrt{3}}$$
 (in meter)

Ans. 1

Sol. 9 & 10



$$\frac{KQ}{(2+R+x)} = \frac{KQ}{\sqrt{3}} = \frac{\sqrt{3}}{x+R}$$
  
 $\sqrt{3} (x+R) = 2 + R + x$   
 $(\sqrt{3} - 1)x + (\sqrt{3} - 1)R = 2$ 

 $\frac{KQ}{2-x'} = \frac{\frac{KQ}{\sqrt{3}}}{x'}$ 

 $\sqrt{3}x' = 2 - x'$ 

 $x' = \frac{2}{\sqrt{3}+1}$ 

x' + x = R

 $\frac{2}{\sqrt{3}+1} + x = R$ 

using equation

 $R = \sqrt{3} m$ 

V at A:  

$$\frac{KQ}{2-x'} = \frac{KQ}{\sqrt{3}}$$

$$\sqrt{3}x' = 2-x'$$

$$x' = \frac{2}{\sqrt{3}+1}$$

$$x' + x = R$$

$$\frac{2}{\sqrt{3}+1} + x = R$$

$$\frac{2}{\sqrt{3}+1} + x = R$$

$$2 + (\sqrt{3}+1)x = (\sqrt{3}+1)R$$

$$x = \frac{(\sqrt{3}+1)R-2}{\sqrt{3}+1}$$

$$(\sqrt{3}+1)R - (\sqrt{3}+1)x = 2 \qquad \dots(ii)$$
using equation (i) and (ii)  

$$R = \sqrt{3}m$$

$$x = \frac{(\sqrt{3}+1)\sqrt{3}-2}{\sqrt{3}+1} = \frac{\sqrt{3}+1}{\sqrt{3}+1} = 1m$$

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...(i)



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**11.** A Particle of mass 0.2 kg is moving on the line y = -1. Its velocity at (-10, -1) is zero and acceleration is 10 m/s<sup>2</sup> (constant). Match the correct options.



- (A) When x-coordinate of particle is zero torque ( $\tau$ ) on particle about origin is ( $2\hat{K}$ ) N-m.
- (B) When x-coordinate of particle is 10, torque ( $\tau$ ) on particle about origin is  $4\hat{K}$  (N-m).
- (C) At x = 10m, angular momentum ( $\vec{L}$ ) of particle about origin is 40 kg-m<sup>2</sup>/sec  $\hat{K}$ .
- (D) A Particle reaches (10, -1), 2 seconds after it starts.

#### Ans. (A, C, D)

**Sol.** 
$$\vec{\tau}$$
 on particle will be constant =  $r_1 F \hat{K}$ 

= (10) (0.2) (10)  
= 20 N-m 
$$\hat{K}$$

 $\vec{L}$  at  $(10, -1) = r_{\parallel} mv \hat{K}$ 

= 
$$10 \times 0.2 \times \sqrt{2 \times 10 \times 20}$$
  
=  $10 \times 0.2 \times 20 = 40 \text{ kg-m}^2/\text{s} \hat{\text{K}}$ 

time to move to (10, -1)

$$20 = \frac{1}{2}(10)(t^2) \Longrightarrow t = 2 \sec(t)$$

- **12.** Which of the following is/are correct?
  - (A) Range of Lyman and Balmer series wavelengths does not overlap.
  - (B) Balmer and Paschen series wavelength do overlap.
  - (C) Ratio of maximum to minimum wavelength in Balmer series is  $\frac{9}{5}$

(D) The wavelength of Lyman series is of the order of  $\left[1 + \frac{1}{n^2}\right]\lambda_0$ , where  $\lambda_0$  is shortest wavelength

**O** 

and n is integer

Ans. (A,C) 
$$1 \quad 2 \begin{bmatrix} 1 & 1 \end{bmatrix}$$

Sol.

$$\frac{1}{\lambda} = RZ^{2} \left[ \frac{1}{n_{1}^{2}} - \frac{1}{n_{2}^{2}} \right]$$
$$\frac{\lambda_{max}}{\lambda_{min}} = \frac{\left[ \frac{1}{2^{2}} - \frac{1}{\infty} \right]}{\left[ \frac{1}{2^{2}} - \frac{1}{3^{2}} \right]} = \frac{9}{5}$$



13. A light ray originates in a medium of refractive index  $n_1$  incident on surface  $s_1$  at an angle  $\theta$ . (here sin $\theta$  is slightly greater than  $\frac{1}{n_1}$ )



(A) If  $n_2 = 1$ , ray gets reflected back.

(B) If  $n_2 > n_1$ , ray gets reflected back at  $s_2$ 

(C) If  $n_2 > n_1$ , ray will finally get into Air.

(D) If  $n_2 < n_1$ , ray will finally get reflected back into  $n_1$ .

#### Ans. (A,B,D)



Air

$n_2$ :	
$n_1 \qquad \theta \qquad S_1$	
$\sin\theta > \frac{1}{n_1}$	<b>KIZCC</b>
(A) If $n_2 = 1$ i.e. $\theta > c$	

Light ray will reflected back into medium  $n_1$ .

(B) If  $n_2 > n_1$  light ray travelling from rarer to denser medium

 $\therefore$  it will move to medium  $n_2$ 

$$\sin\theta > \frac{1}{n_1}$$
$$\therefore r > \sin^{-1}\left(\frac{1}{n_2}\right)$$

Right ray reflect back to n<sub>2</sub>



(D) If  $n_2 < n_1$ , ray will refract from  $S_1$  but it cannot refract through  $S_2$  because  $S_1$  and  $S_2$  are parallel, ray reflect back to  $n_1$ 



### Image: Second State of the second state of

Cylinder of diameter d is placed as shown on fixed wedge & contains liquid of density p. 14. If  $\beta = \frac{P_1 - P_2}{\rho g d}$  when P<sub>1</sub> and P2 are pressures at points 1 & 2 respectively, then choose correct options. [a is acceleration of cylinder]



Ans. (A,D)

**Sol.** is correct because if  $a = \frac{g}{\sqrt{2}}$ , contains is in free fall.

If 
$$a = \frac{g}{2}$$
  
 $\ell_{12} = \sqrt{2}d$   
&  
 $P_1 + \frac{\rho g \sqrt{2} d}{\sqrt{2}} - \rho \left(\frac{g}{2}\right) \sqrt{2} d = P_2$   
 $\therefore P_1 - P_2 = \rho g d \left(\frac{1}{\sqrt{2}} - 1\right)$ 

In the diagram shown below a semi-circular wire is moving with constant speed 3 m/s on two 15. parallel long conducting rails of sufficient length in the magnetic field of a current carrying wire of infinite length. Then



(A) The maximum charge on the capacitor is  $8.4 \times 10^{-12}$  C

- (B) The maximum charge on the capacitor is  $3.1 \times 10^{-6}$  A (C) The maximum charge on the capacitor is  $8.4 \times 10^{-10}$  C
- (D) The maximum current in the circuit is  $1.2 \times 10^{-5}$  A

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Ans. (A,B)
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- 16. A cylinder is placed on a rough horizontal surface. A force F is applied as shown in figure such that
  - it rolls without slipping. Coefficient of friction between the cylinder and the horizontal surface is  $\mu$ .



- (A) Acceleration of centre of mass does not depend on whether cylinder is solid or hollow.
- (B) The magnitude of force of friction will be always  $\mu$  mg.
- (C) Acceleration of centre of mass is  $\frac{F}{2m}$  for a thin walled cylinder.
- (D) Maximum acceleration of centre of mass is  $2 \mu g$

Ans. (C, D)



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Sol. (A)  

$$F - f = ma_{cm}$$

$$F = I\alpha$$

$$a_{cm} = R\alpha$$

$$F = \frac{Ia_{cm}}{R^2} = ma_{cm}$$

$$a_{cm} = \frac{F}{J'_{R^2} + m}$$
(B)  $fR = \frac{IF}{\left(\frac{I}{R^2} + m\right)R}$ 

$$f = \frac{F}{\left(\frac{I}{R^2} + m\right)R}$$

$$f = \frac{F}{1 + mR^2}$$
depends on F  
(C) For thin walled cylinder I = mR^2,  $a_{cm} = \frac{F}{2m}$ 
(D)  $\mu$  mg R = I $\alpha$   $\alpha = \frac{\mu mgR \times 2}{mR^2}$ 

$$\alpha = \frac{2\mu g}{R}$$

17. A rod of mass M and length 'a' has a disc of mass M and radius  $\frac{a}{4}$  placed at a distance  $\frac{3a}{4}$  from fixed end of the rod. The rod rotates about axis passing through left end and disc rotates with angular velocity 4 $\omega$  about its axis. If angular momentum of system about OO' is  $\frac{nMa^2\omega}{48}$ . Find n



Ans. 49

Sol 
$$\frac{Ma^2}{3}\omega + \frac{M\left(\frac{a}{4}\right)^2}{2} 4\omega + M\left(\frac{3a}{4}\right)^2 \omega$$
$$= \frac{Ma^2\omega}{3} + \frac{Ma^2\omega}{8} + \frac{9Ma^2\omega}{16}$$
$$= \frac{16Ma^2\omega + 6Ma^2\omega + 27Ma^2\omega}{48}$$
$$= \frac{49Ma^2\omega}{48}$$





18. A small particle of initial temperature 200 K is placed at the centre of a large spherical container of temperature 0 K. At time t<sub>1</sub> temperature of particle was 100 K and at time t<sub>2</sub> temperature of small particle becomes 50 K. Then <sup>t<sub>2</sub></sup>/<sub>t<sub>1</sub></sub> will be. [All surfaces behaves as a black body]

Ans. 9

Sol.



**19.** Singly charge sulphur atom and alpha particle are accelerated by same potential difference and then these are projected normally in to uniform magnetic field, so that they are moving in circle. What will be the ratio of their radius.

Ans. 4

Sol. 
$$r = \frac{\sqrt{2mqV}}{qB} \Rightarrow r \propto \sqrt{\frac{m}{q}}$$
  
 $\Rightarrow \frac{r_1}{r_2} = \sqrt{\frac{m_1}{m_2} \left(\frac{q_2}{q_1}\right)} = \sqrt{\frac{32}{4} \frac{(2)}{(1)}} = 4$ 

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