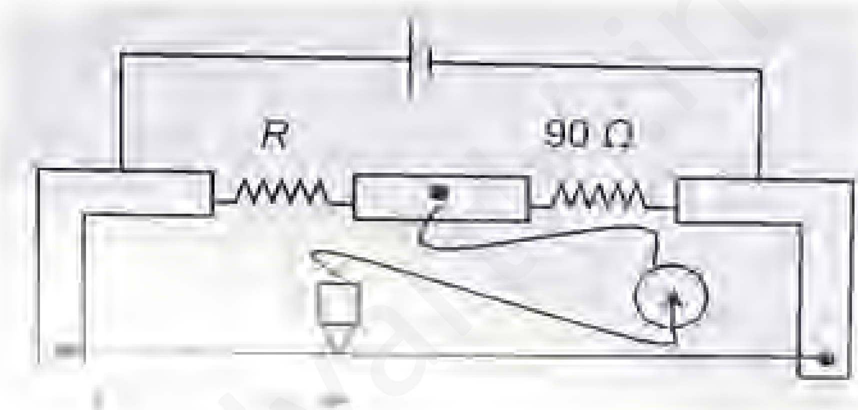
JEE Advanced 2014 Paper- 2(Code – 6)

PART I : PHYSICS

SECTION - I : (Only One Option Correct Type)

1. During an experiment with a metre bridge, the galvanometer shows a null point when the jockey is pressed at 40.0 cm using a standard resistance of 90 Ω, as shown in the figure. The least count of the scale used in the metre bridge is 1 mm. The unknown resistance is



(A) 60 ± 0.15

(B) $135 \pm 0.56\Omega$

(C) $60 \pm 0.25\Omega$

(D) $135 \pm 0.23\Omega$

Sol. $l_1/l_2 = R/a$ $a = 90\Omega$

$\Rightarrow R = a\, l_1/l_2$

$\Delta R/R = \Delta l_1/l_2 + \Delta l_1/l_2$

$\Rightarrow \Delta R = R[\Delta l_1/l_1 + \Delta l_2/l_2]$

$\Rightarrow \Delta R = 6\ [0.1/60 + 0.1/40 * 3/2]$

$\Delta R = 2.5 * 0.1 = 0.25$

$R = 60 \pm 0.25.$

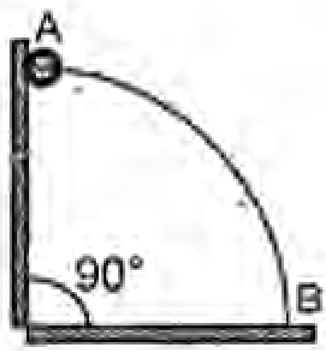
2. A wire, which passesthrough the hole in a small bead, is bent in the form of quarterof a circle. The wire is fixed vertically on ground as shown in the figure. The bead isreleased from near the top of the wire and it slides along the wire without friction. As the bead moves from A to B, the force it applies on the wire is

(A) alway radially outwards.

(B) always radially inwards.

(C) radially outwards initially and radially inwards later.

(D) radially inwards initially and radially outwards later.



Sol:-⇒ $mgh = \frac{1}{2} mv^2$

$mg\cos\theta - N = mv^2/R$

$mg\cos\theta - N = 2mg\,h/R$

after $h = R/2$,

⇒ N should be in words an lead

⇒ N should be out words and wire

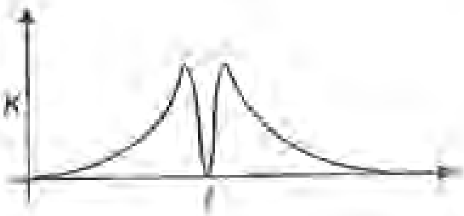
(∵ Action – Reaction pair)

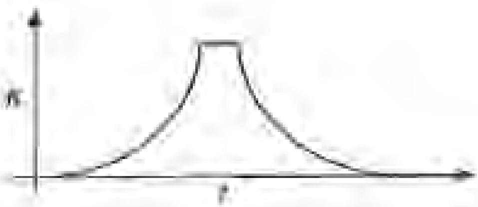
Force appliedan the wire (normal) changes from radially inwords initially to radially outwords alter.

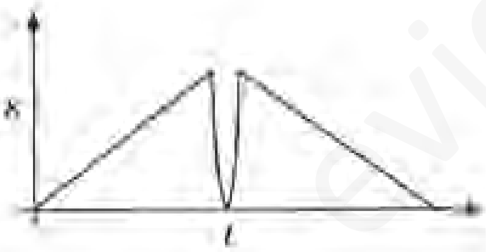
3. A tennis ball is dropped on a horizontal smooth surface. It bounces back to its original position after hitting the surface. The force on the ball during the collision is proportional to the lenth of compression of the ball. Which one of the following sketches describes the

variation of its kinetic energy K with time t most appropriately ? The figures are only illustrative and not to the scale.

(A)


(B)


(C)


(D)


Sol:-V = gt (dropped from ∝ height u = 0)

K.E> = 1/2 mv^2

⇒ k.e. = 1/2 M GT^2

⇒ k.e. ∝ T^2

4. . A glass capillary tube is of the shape of a truncated cone with an apex angle α sothat its two ends have cross sections of different radii. When dippedin watervertically, water rises in it to a height h, where the radius of its cross section is bIf the surface tension of

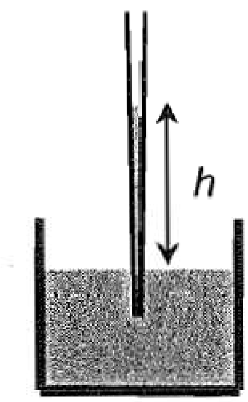
Water is S, its density is ρ, and its contact angle with glass is $\theta$the value of $h$will be (g is the acceleration due to gravity)

(A) 2s/bpg cos (θ – α)

(B) 2s/bpg cos (θ + α)

(C) 2s/bpg cos (θ – α/2)

(D) 2s/bpg cos (θ + α/2)



Sol:-For the lower meniscus fending the contact angle,, with the contacting layer

From the geometry,

Angle formed with the radon will be $(\boldsymbol{\theta} + \propto/2)$

So, height, h = 25/rpgcos $(\boldsymbol{\theta} + \propto/2)$

Also, calculating for ensure below to the liquid surface will be

P_{Lawer} $(P_0 - 2T/R + Pgh)$

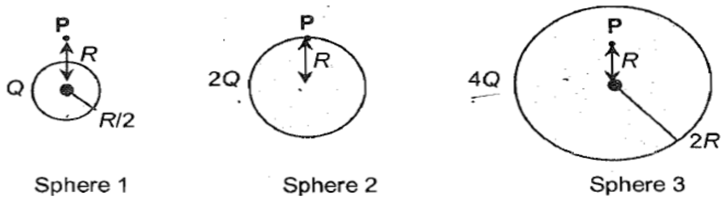
5. Charges Q, 2Q and 4Q are uniformly distributed in three dielectric solid spheres 1, 2and 3 of radii R/2, R and 2R respectively, as shown in figure. If magnitudes of the electric fields at point P at a distance R from the centre of spheres 1, 2 and 3 are E_1, E_2 and E_3 respectively, then

(A) $E_1 > E_2 > E_3$

(B) $E_3 > E_1 > E_2$

(C) $E_2 > E_1 > E_3$

(D) $E_3 > E_2 > E_1$



Sol. $E_1 = kQ/R^2$ $E_2 = k2Q/R^2$

Q inside sphere of radius R

$q = 4Q/4/3\pi * 5R^3\ 4/3\ \pi R^3 = Q/2$

$E_3 = kQ/2KR^2$

Clearly, $E_2 > E_1 > E_3$

6. Parallel rays of light of intensity I = 912 Wm^{-2} are incident on a spherical black body kept in surroundings of temperature 300 K. Take Stefan-Boltzmann constant$\sigma = 5.7 \times 10^{-8}$ $Wm^{-2}K^{-4}$ and assume that the energy exchange with the surroundings is only through radiation. The final steady state temperature of the black body is close to

(A) 330 *K*

(B) 660 *K*

(C) 990 *K*

(D) 1550 *K*

Sol. Energy absorbed

Per unit time = IA/4

Energy radiated = 6 A $(T^4 - T_0^4)$

Per unit time

$T \rightarrow$ final temp.

$T_0 \rightarrow$ surrounding temp

$IA/\text{-}4 = 6A (T^4 - T_04) \Rightarrow T_0^4 = T_0^4 + I/46 \Rightarrow T = 330$ K

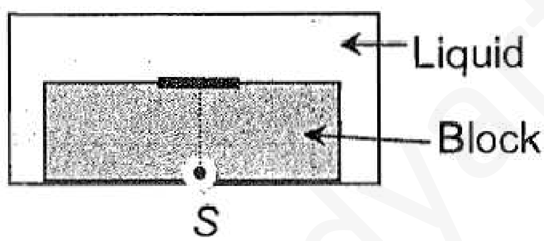
7. A point source S is placed at the bottom of a transparent block of height 10 *mm* andrefractive index 2.72. It is immersed in a lower refractive index liquid as shown in the figure. It is found that the light emerging from the block to the liquid forms a circular bright spot of diameter 11.54 *mm* on the top of the block. The refractive index of the liquid is

(A) 1.21

(B) 1.30

(C) 1.36

(D) 1.42



Sol.$Sin\theta_c = n_l/n_b$

$N_l = n_b Sin\theta_c$

$N_l = 2.72 * 5.27/10 = 1.36$

8. A metal surface is illuminated by light of two different wavelengths 248 *nm* and 310 *nm*. The maximum speeds of the photoelectrons corresponding to these wavelengths are μ_1 and μ_2, respectively. if the ratio μ_1:μ_2 = 2 : 1 and *hc* = 1240 *eVnm*, the work function of the metal is nearly

(A) 3.7 *eV*

(B) 3.2 *eV*

(C) 2.8 *eV*

(D) 2.5 *eV*

Sol. $E = \lambda C/\lambda$

K.E. = E – ϕ

$K.E._1/K.E._2 = E_1 - \phi/E_2 - \phi$

$1/2\ mu_1 2/1/2\ mu_2 2 = 1240/\lambda_1 - \phi/1240/\lambda_2 - \phi$

$4/1 = 1240/248 - \phi/1240/310 - \phi$

⇒ = 3.7 eV

9. If λ_{Cu} is the wavelength of Kα X-ray line of copper (atomic number 29) and λ_{Mo} is the wavelength of the Kα X-ray line of molybdenum (atomic number 42), then the ratio $\lambda_{Cu}/\lambda_{Mo}$ is close to

(A) 1.99

(B) 2.14

(C) 0.50

(D)0.48

Sol. $\lambda = hC/E_K - E_L$ for K_x

For K_x, $DE = hv = Rhc\ (Z^2)\ (1/1^2 - 1/2^2)$

$= \frac{3}{4}\ Rhc\ Z^2$

$\lambda_{cu}/\lambda_{mo} = Z_{mo}2/Z_{cu}2 = 2.14$

10. A planet of radius R = 1/10 x (radius of Earth) has the same mass density as Earth.Scientists dig a well of depth R/5 on it and lower a wire of the same length and of linearmass density 10^{-3} kgm^{-1} into it. If the wire is not touching anywhere,the forceapplied at the top of the wire by a person holding it in place is (take the radius of Earth = 6 x 10^6m and the acceleration due to gravity on Earth is 10 ms^{-2})

(A) 96 *N*

(B) 108 N

(C) 120 N

(D) 150 N

Sol. $R_P = R_e/10$ $\rho_P = \rho_e$

(B) $M_e/4/3\pi R_e3 = M_P/4/3\pi R_e3 * 1000$

$M_P = M_e/1000$

$dF = GM_P/R_P^3 \times \lambda dx$; $F = GM_e\lambda/R_P^3 \int_{\frac{4}{5}R_P}^{R_P} x\,dx$

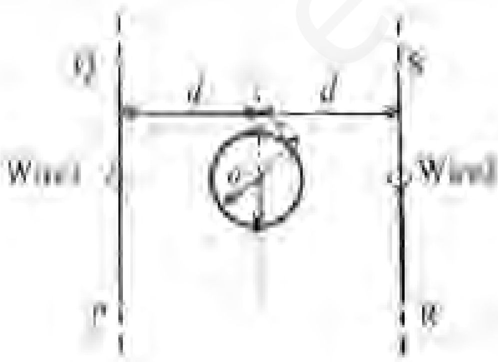
$\Rightarrow F = GM_e\lambda/2R_P^3\, x^2$

$\Rightarrow F = 108$ N.

SECTION — 2 : Comprehension Type (Only One Option Correct)

Paragraph For Questions 11 & 12

The figure shows a circular loop of radius a with two long parallel wires (numb 1 and 2) all in the plane of the paper. The distance of each wire from the centre of the is The loop and the wires are carrying the same current I The current in the loopthe counterclockwise direction if seen from above.



11. When d a but wires are not touching the loop, it is found that the net magnetic 5 on the axis of the loop is zero at a height h above the loop. In that case

(A) current in wire 1 and wire 2 is the direction PQ and RS, respectively and h

(B) current in wire 1 and wire 2 is the direction P0 and SR, respectively and h

(C) current in wire 1 and wire 2 is the direction PQ and SR, respectively a h 1.2a

(D) current in wire 1 and wire 2 is the direction PQ and RS, respectively a 1.2a

Sol. (c) Electrice field due to wire = $\mu_0 I/2\lambda\sqrt{d^2 + h^2}$

Electric field due to circular 100/p = $\mu_0 I/2(q^2 + h^2)^{3/2}$

To cancel out the electric field due to circular loop, equivalent electric field due to wires should be opposite.

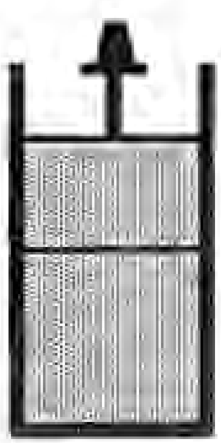
Current in wires are in PQ& SR direction

12. Consider d » a, and the loop is rotated about its diameter parallel to the wires by 3° from the position shown in the figure. If the curredirections, the torque on the loop at its new position will be (assume that the net fig due to the wires is constant over the loop)

Sol. (B) $\vec{\tau} = \vec{M} * \vec{B}$

Paragraph For Questions 13& 14

In the figure a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat. The lower compartment of the container is filled with 2 moles of an ideal monatomic gas at 700 K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400 K. The heat capatities per mole of an idealmonatomic gas are C_V = 3/2R, C_P= 5/2R, and those for an ideal diatomic gas are C_V = 5/2 R, C_P= 7/2 R.



13. Consider the partition to be rigidly fixed so that it does not move. When equilibrium achieved, the final temperature of the gases will be

(A) 550 K

(B) 525 K

(C) 513 K

(D) 490 K

fry time they achieve equilibrium will begases in both compartments is the same. Then total work done by the gas.

Sol.(D) $n_{dia}C_{Pdia}(T_f - T_{dia}) = n_{mono}(v_{mon}(T_{mono} - T_f)$

$\therefore V_{dia} = n_{mono}$

7/2 (T - 400) = 3/2 (700 - T)

7T - 2800 = 2100 - 3T

10T = 4900

T = 490 K

14. Now Consider the partition to be free to move without friction so that the pressure gases in both compartments is the same. Then total work done by the gase to time they achieve equilibrium will be

(A) 250 R

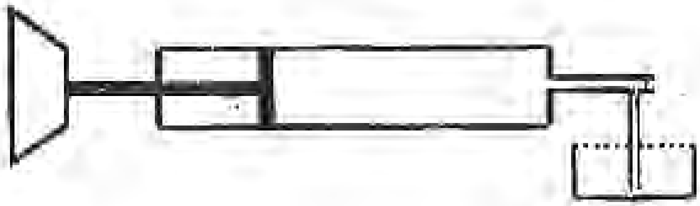
(B) 200 R

(C) 100 R

(D) -100 R

Paragraph For Questions 15& 16

A spray gun is shown in the figure where a piston pushes air out of a nozzle. A thin tube of uniform cross section is connected to the nozzle. The other end of the tube is in a small liquid container. As the piston pushes air through the m bB--li-g-1-l-i cl_ from the container rises into the nozzLe—ancl.is spiay ediAut. For the s m showri.li fe- radiroTtifepTriarTdirle nozzle are 20 mm and 1 mm res ectivel The upper end of the container l to the atmosphere.



Sol. Ans. 14.(D).

sol. $\Delta W_1 + \Delta U_1 = \Delta Q_1$

$\Delta W_2 + \Delta U_2 = \Delta Q_2$

$\Delta Q_1 + \Delta Q_2 = 0$

$7/2\,R\,(T - 400) = 5/2\,R\,(700 - T)$

$\Rightarrow T = 6300/12 = 525$ k

So $\Delta W_1 + \Delta W_1 = 2\,.\,R\,.(525 - 400) + 2R(525 - 700)$

$= +250R - 350R$

$= -100R$

15. If the piston is pushed at a speed of 5 mms-1 . the air comes out of the nozzle with a speed of

(A) 0.1 ms-1 (B) 1 ms-1 Piece ms-1 (D) 8 ms-1

Sol.(c) $A_1 v_1 = A_2 V_2$

$\pi d_1^2 v_1 = \pi d_2^2 v_2$

$V_2 = d_1^2/d_2^2 v_1 = 2$ ms - 1

16.If the density of air is pa and that of the liquid pℓ, then for a given pistons speech therate (volume per unit time) at which the liquid is sprayed will be proportional to

(A) $\sqrt{\frac{\rho a}{\rho \ell}}$

(B) $\sqrt{\rho a\, \rho \ell}$

(C) $\sqrt{\frac{\rho \ell}{\rho a}}$

(D) $\rho \ell$

Sol. Ans. 16. (A). $p_0 - 1/2\rho_a v_a^2$

$= p - 1/2\rho_f v_f^2 - \rho_f gh$

$v_f = \sqrt{\rho_a/\rho_f v_a - 2gh}$

SECTION — 3 Matching List Type (Only One Option Correct)

17. A person in a lift is holding a water jar, which has a small hole at the lower end of its side. When the lift is at rest, the water jet coming out of the hole hits the floor of the lift at a distance d of 1.2 m from the person. In the following, state of the lift's motion is • iven in List I and the distance where the let hits the floor of the lift is given in List II. Match the statements from List I with those in List II and select the correct answer using the code given below the lists.Code :

List I

P. Lift is accelerating vertically up.

Q. Lift is accelerating vertically down With an acceleration less than the gravitation acceleration

R. Lift is moving vertically up with constant speed

s. Lift is falling freely.

List II

1. d = 1.2 m
2. d > 1.2 m
3. d < 1.2 m

No water leaks out of the jar

(A) P-2, Q-3, R-2, S-4

(B) P-2, Q-3, R-1, S-4

(C) P - 1, Q-1,R-1, S-4

(D) P-2, Q-3, R-1, S-1

Sol. Ans. 17. (B). Velocity form orifice = $\sqrt{2gh}$

n height of water in vessel V increases, horizontal range increases.

V↑ R↑

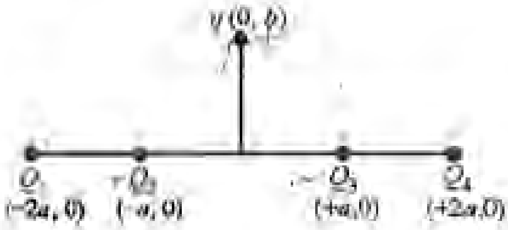
Lift going up ;geff = g + a

Lift going down ;geff = g – a

Free fall = geff = 0

Uniform velocity ;geff = 0

18. Four charges Q_1, Q_2, Q_3 and Q_4 of same magnitude are fixed along the x axis2a, —a, a and +2a, respectively. A positive charge q is placed on the posit-y axis at a distance b > 0. Four options of the signs of these, charges are _givenList I. The direction of the forces on the charge qis given in List II. Match List I with List II and select the correct answer using the code given below the lists.



List I

P. Q_1, Q_2, Q_3, Q_4 all positive

Q. Q_1, Q_2 positive; Q_3, Q_4 negative

R. Q_1, Q_4 positive; Q_2, Q_3 negative

S. Q_1, Q_3 positive; Q_2, Q_4 negative

List II

1. +x
2. –x
3. + y
4. –y

Code

(A) P-3, Q-1, R-4, S-2

(B) P-4, Q-2, R-3, S-1 m

(C) P-3, Q-1, R-2, S-4

(D) P-4, Q-2, R-1, S-3

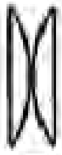
(C) P-3, 0-1, R-2, S-

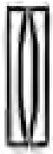
Sol.(A). $\vec{F} = \pm KQq/r^2\hat{r}$

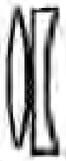
19. Four combinations of two thin lenses are given in List I. The radius of curvature o curved surfaces is r and the refractive index of all the lenses is 1.5. Match combinations in List I with their focal length in List II and select the correct answer u the code given below the lists

List I

P. 

Q. 

R. 

S. 

List II

1. 2r
2. r/2
3. -r
4. r

Code :

(A) P-1, Q-2, R-3, S-4

(B) P-2, Q-4, R-3, S-1

(C) P-4, Q-1, R-2, S-3

(D) P-2, Q-1, R-3, S-4

Sol. $1/f = 1/f_1 + 1/f_2$

$1/f = (n-1)\,[1/R_1 + 1/R_2]$

For Q, $f = r/2$

For Q, $f = r$

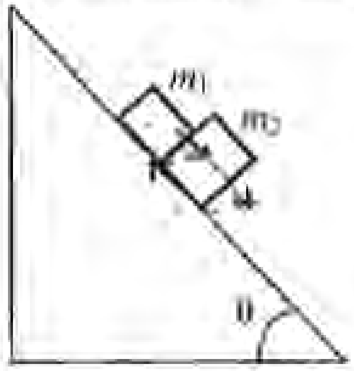
R, $f = -r$

S, $f = 2r$

20. A block of mass $m_1 = 1$ kg another mass $m_2 = 2$kg, are placed together (see figure) on an inclined plane with angle of inclination θ are given in List I. The coefficient of friction between the block m_1 and the plane is always zero. The coefficient of static and

dynamic friction between the block m_2 and the plane are equal to $\mu = 0.3$. In List II expressions for the friction on block m_2 are given. Match the correct expression of the friction in List II with the angles given in List I, and choose the correct option. The acceleration due to gravity is denoted by g.

[Useful information : tan (5.5°) ≈ 0.1 ; tan (11.5°) ≈ 0.2; tan (16.5°) ≈ 0.3]



List I

P. $\theta = 5°$

Q. $\theta = 10°$

R. $\theta = 15°$

S. $\theta = 20°$

List II

1. $m_2 g \sin\theta$
2. $(m_1 + m_2) g \sin\theta$
3. $\mu m_2 g \cos\theta$
4. $\mu(m_1 + m_2) g \cos\theta$

(A) P-1, Q-1, R-1, S-3

(B) P-2, Q-2, R-2, S-3

(C) P-2, Q-2, R-2, S-4

(D) P-2, Q-2, R-3, S-3

Sol.(D)

$(m_1 + m_2)$ $g\sin\theta = f_s = \mu m_2 g \cos\theta$

$[N = m_2 g \cos\theta]$

$\tan\theta = \mu m_2/(m_1 + m_2) = 0.2$

$\Rightarrow \theta = 11.5^0$

if $\theta > 11.5^0$ slipping ; $f_s = \mu N$

$\theta < 11.5^0$, rest ; $f_s = (m_1 + m_2) g \sin\theta$