Topic : Gravitation and current electricity

1. A body weighs $49 \mathrm{~N}$ on a spring balance at the North Pole. What will be its weight recorded on the same weighing machine, if it is shifted to the equator?

[Use, $g=\dfrac{GM}{R^2}=9.8 \mathrm{~m/s}^2$ and radius of earth, $R=6400 \mathrm{~km}$]

A. $49 \mathrm{~N}$

B. $49.83 \mathrm{~N}$

C. $49.17 \mathrm{~N}$

D. $48.83 \mathrm{~N}$

Let the mass of the body be M.

So, weight at the North Pole, $Mg=49 \mathrm{~N}$

Now, at the equator, gravitational acceleration is less than that at the North Pole due to rotation of the earth, and it is given as:
$g'=g-\omega^2 R$

Where, ω is angular speed of rotation of earth, R is radius of the earth and g is gravitational acceleration at the pole.

Now, Weight at the equator, $Mg'=M\left(g-\omega^2 R\right)$

So, weight at the equator will be less than that at the North Pole.

From the given option, only fourth option is having value lesser than $49 \mathrm{~N}$.

2. Four identical particles of equal masses $1 \mathrm{~kg}$ are made to move along the circumference of a circle of radius $1 \mathrm{~m}$ under the action of their own mutual gravitational attraction. The speed of each particle will be :
[Assume particles are at the vertices of a square, also G is Gravitational Constant]

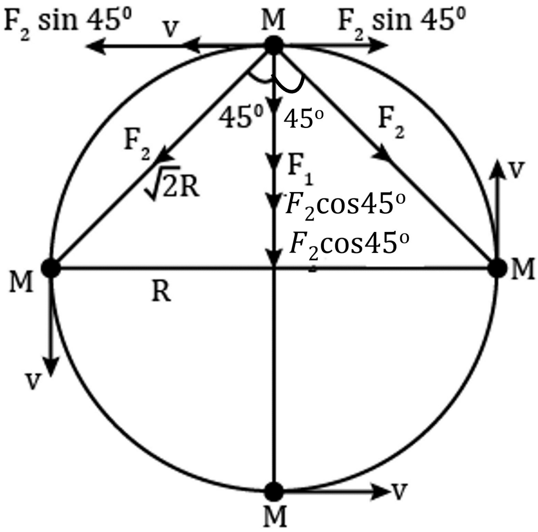
A. $\frac{\sqrt{(1+2\sqrt{2})G}}{2}$

B. $\sqrt{G(1+2\sqrt{2})}$

C. $\sqrt{\frac{G}{2}(2\sqrt{2}-1)}$

D. $\sqrt{\frac{G}{2}(1+2\sqrt{2})}$

FBD of one of the particles is shown in the figure.



Centripetal Force (F_C) is given by,

$$F_C = F_1 + F_2\cos 45^\circ + F_2\cos 45^\circ$$

$$\Rightarrow F_1 + 2F_2\cos 45^\circ = F_C$$

$$\Rightarrow \frac{GM^2}{(2R)^2} + 2\left[\frac{GM^2}{(\sqrt{2}R)^2}\cos 45^\circ\right] = \frac{Mv^2}{R}$$

$$\Rightarrow \frac{GM^2}{4R^2} + 2\left[\frac{GM^2}{2R^2} \times \frac{1}{\sqrt{2}}\right] = \frac{Mv^2}{R}$$

$$\Rightarrow \frac{GM^2}{4R^2} + \frac{GM^2}{\sqrt{2}R^2} = \frac{Mv^2}{R}$$

$$\Rightarrow v = \sqrt{\frac{GM}{4R} + \frac{GM}{\sqrt{2}R}}$$

$$\Rightarrow v = \sqrt{\frac{GM}{R}\left(\frac{1+2\sqrt{2}}{4}\right)}$$

$$\Rightarrow v = \frac{1}{2}\sqrt{\frac{GM}{R}(1+2\sqrt{2})}$$

Given, $M = 1\ \text{kg}$ and $R = 1\ \text{m}$

$$\Rightarrow v = \frac{\sqrt{(1+2\sqrt{2})G}}{2}$$

3. Consider two satellites, S_1 and S_2 with periods of revolution, 1 hr and 8 hr respectively revolving around a planet in circular orbits. The ratio of angular velocity of satellite S_1 to the angular velocity of satellite S_2 is

A. $8:1$

B. $1:8$

C. $2:1$

D. $1:2$

Given:
Ratio of time periods,
$$\frac{T_1}{T_2} = \frac{1}{8}$$

We know that,
$$\omega = \frac{2\pi}{T}$$

$$\Rightarrow \omega \propto \frac{1}{T}$$

$$\Rightarrow \frac{\omega_1}{\omega_2} = \frac{T_2}{T_1}$$

$$\Rightarrow \frac{\omega_1}{\omega_2} = \frac{8}{1}$$

$$\Rightarrow \omega_1 : \omega_2 = 8 : 1$$

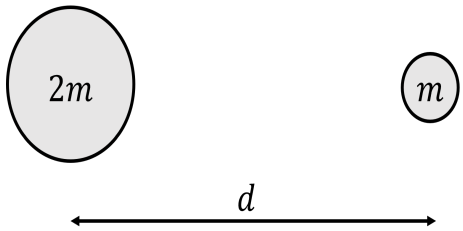
4. Two stars of masses m and $2m$ at a distance d rotate about their common centre of mass in free space. The period of revolution is

A. $2\pi\sqrt{\dfrac{d^3}{3Gm}}$

B. $\dfrac{1}{2\pi}\sqrt{\dfrac{3Gm}{d^3}}$

C. $\dfrac{1}{2\pi}\sqrt{\dfrac{d^3}{3Gm}}$

D. $2\pi\sqrt{\dfrac{3Gm}{d^3}}$



This is a double star system in which both the stars revolve around the centre of mass of the system with the same angular frequency ω (say).

On planet of mass m :

$F_{\text{gravitation}} = F_{\text{centripetal}}$

$$\Rightarrow \frac{G(m)(2m)}{d^2} = m\omega^2 \times \frac{2d}{3}$$

[Distance of COM of the system from the star of mass $m = \frac{2d}{3}$]

$$\Rightarrow \frac{2Gm}{d^2} = \omega^2 \times \frac{2d}{3}$$

$$\Rightarrow \omega^2 = \frac{3Gm}{d^3}$$

$$\Rightarrow \omega = \sqrt{\frac{3Gm}{d^3}}$$

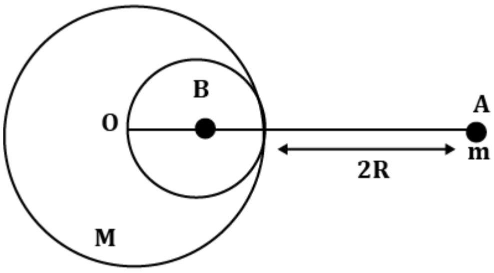
We know that,
$\omega = \frac{2\pi}{T}$

So, $T = \frac{2\pi}{\omega}$

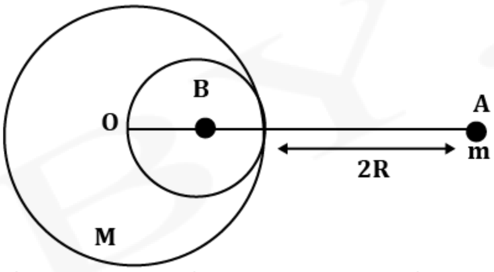
$$\Rightarrow T = \frac{2\pi}{\sqrt{\frac{3Gm}{d^3}}}$$

$$\Rightarrow T = 2\pi\sqrt{\frac{d^3}{3Gm}}$$

5. A solid sphere of radius R gravitationally attracts a particle placed at $3R$ from its centre with a force F_1. Now, a spherical cavity of radius $R/2$ is made in the sphere as shown in the figure and the force becomes F_2. The value of $F_1 : F_2$ is -



- A. $41 : 50$
- B. $36 : 25$
- C. $50 : 41$
- D. $25 : 36$



Gravitational field intensity before making cavity at A,

$$g_1 = \frac{GM}{(3R)^2} = \frac{GM}{9R^2} \quad \ldots .(1)$$

Gravitational field intensity after making cavity at A,

$$g_2 = \frac{GM}{(3R)^2} - \frac{G(M/8)}{(2R + R/2)^2} = \frac{41GM}{450R^2} \quad \ldots .(2)$$

So,

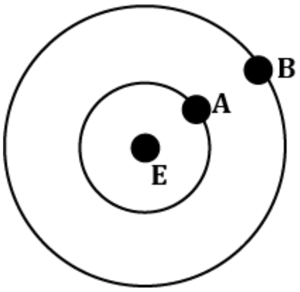
$$F_1 : F_2 = mg_1 : mg_2 = g_1 : g_2$$

$$\Rightarrow F_1 : F_2 = \frac{GM}{9R^2} : \frac{41GM}{450R^2}$$

[From (1) and (2)]

$$\Rightarrow F_1 : F_2 = 50 : 41$$

6. Two satellites A and B of masses $200 \mathrm{~kg}$ and $400 \mathrm{~kg}$ are revolving round the earth at height of $600 \mathrm{~km}$ and $1600 \mathrm{~km}$ respectively. If T_A and T_B are the time periods of A and B respectively then the value of $T_B - T_A$ is:
[Given : Radius of earth$= 6400 \mathrm{~km}$, Mass of earth$= 6 \times 10^{24} \mathrm{~kg}$]



A. $4.24 \times 10^2 \mathrm{~s}$

B. $3.33 \times 10^2 \mathrm{~s}$

C. $1.33 \times 10^3 \mathrm{~s}$

D. $4.24 \times 10^3 \mathrm{~s}$

We know that, time period,

$$T = 2\pi\sqrt{\frac{r^3}{GM_e}}$$

$$T_B - T_A = 2\pi\sqrt{\frac{r_B^3}{GM_e}} - 2\pi\sqrt{\frac{r_A^3}{GM_e}}$$

$$\Rightarrow T_B - T_A = 2\pi \times \frac{1}{\sqrt{GM_e}}\left(\sqrt{r_B^3} - \sqrt{r_A^3}\right)$$

$$\Rightarrow T_B - T_A = 2\pi \times \frac{1}{\sqrt{6.67 \times 10^{-11} \times 6 \times 10^{24}}}\left(\sqrt{(8000 \times 10^3)^3} - \sqrt{(7000 \times 10^3)^3}\right)$$

$$\Rightarrow T_B - T_A \approx 1.33 \times 10^3 \mathrm{~s}$$

7. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A : The escape velocities of planets A and B are the same, but A and B are of unequal masses.

Reason R : The product of their mass and radius must be the same
$i.e.\ M_A R_A = M_B R_B$.

In the light of the above statements, choose the most appropriate answer from the options given below.

A. Both A and R are correct, but R is **NOT** the correct explanation of A.

B. A is correct, but R is not correct.

C. Both A and R are correct, and R is the correct explanation of A.

D. A is not correct, but R is correct.

We know that, escape velocity,

$$v_e = \sqrt{\frac{2GM}{R}}$$

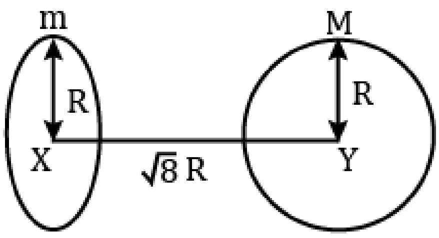
The escape velocities of planets can be equal and their masses and radii can be unequal.

So, for same v_e,

$$\frac{M_A}{R_A} = \frac{M_B}{R_B} \Rightarrow M_A R_B = M_B R_A$$

Therefore, A is correct, but R is not correct.

8. Find the gravitational force of attraction between the ring and sphere as shown in the diagram, where the plane of the ring is perpendicular to the line joining the centres. If $\sqrt{8}$ R is the distance between the centres of a ring (of mass m) and a sphere (of mass M) where both have equal radius R.

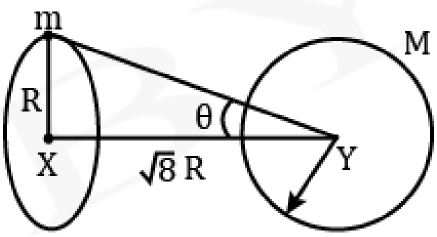


A. $\frac{\sqrt{8}}{9}\frac{GmM}{R}$

B. $\frac{\sqrt{8}}{27}\frac{GmM}{R^2}$

C. $\sqrt{2}\frac{GmM}{R^2}$

D. $\frac{1}{3\sqrt{8}}\frac{GmM}{R^2}$



We know that ,

$$F = ME = M\left(\frac{Gm\sqrt{8}R}{(R^2+(\sqrt{8}R)^2)^{\frac{3}{2}}}\right)$$

[Assuming the sphere as a point mass located at its geometrical centre]

$$F = \frac{GmM\sqrt{8}R}{(9R^2)^{\frac{3}{2}}} = \frac{\sqrt{8}GmM}{(9R^2)^{\frac{3}{2}}}$$

$$F = \frac{\sqrt{8}GmM}{27R^2}$$

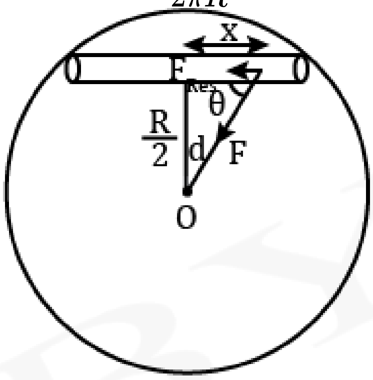
9. Assume that a tunnel is dug along a chord of the earth, at a perpendicular distance $\left(\frac{R}{2}\right)$ from the earth's centre, where R is the radius of the Earth. The wall of the tunnel is frictionless. If a particle is released in this tunnel, it will execute a simple harmonic motion with a time period:

A. $2\pi\sqrt{\frac{R}{g}}$

B. $\frac{1}{2\pi}\sqrt{\frac{g}{R}}$

C. $\frac{2\pi R}{g}$

D. $\frac{g}{2\pi R}$



$\cos\ \theta = \frac{x}{d}$

If displaced from equilibrium position,

$$F_{restoring} = \left(\frac{GMmd}{R^3}\right)\cos\theta$$

$$F_{restoring} = \frac{GMmd}{R^3}.\frac{x}{d} = \frac{GMmx}{R^3}$$

$$a = \frac{GMx}{R^3}$$

we know that the time period given by,

$$T = 2\pi\sqrt{\left|\frac{x}{a}\right|}$$

$$T = 2\pi\sqrt{\frac{x}{\frac{GMx}{R^3}}}$$

$$T = 2\pi\sqrt{\frac{R}{g}} \qquad \left(\because g = \frac{GM}{R^2}\right)$$

10. A planet revolving in an elliptical orbit has :

A). a constant velocity of revolution.

B). the least velocity when it is nearest to the sun.

C). its areal velocity directly proportional to its velocity.

D). its areal velocity inversely proportional to its velocity.

E). a trajectory such that the areal velocity is constant.

Choose the correct statement from the options given below :

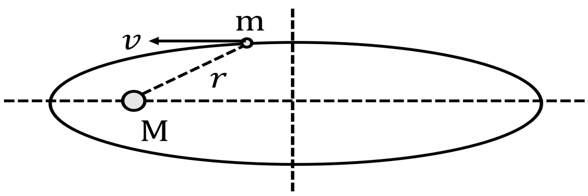
- **A.** A only
- **B.** E only
- **C.** D only
- **D.** C only

From law of conservation of angular momentum,
$I\omega =$ constant
$\Rightarrow mr^2 \times \dfrac{v}{r} =$ constant
So, $mvr =$ constant

$\Rightarrow$ Linear velocity of planet changes as radial distance from the sun changes.

$\Rightarrow$ Linear velocity is inversely proportional to the radial distance from the sun. Therefore, velocity is more when near to the sun.

$\Rightarrow$ Areal velocity, $\dfrac{dA}{dt} = \dfrac{L}{2m} =$ constant



Hence, option (B) is correct.

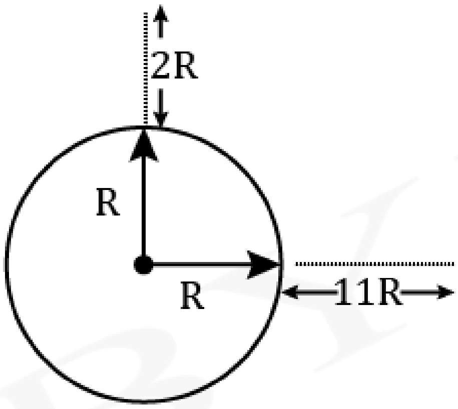
11. A geostationary satellite is orbiting around an arbitrary planet P at a height of $11R$ above the surface of P, R being the radius of P. The time period of another satellite in hours at a height of $2R$ from the surface of P is ____. P has the time period of rotation of 24 hours.

A. $\frac{6}{\sqrt{2}}$

B. 3

C. $6\sqrt{2}$

D. 5



From Kepler's law:

$$T^2 \propto R^3$$

where R is distance of satellite from the centre of the planet.

Since time period of a geostationary satellite is equal to the time period of rotation of planet. In this case that is equal to 24 hours.

Using Kepler's law

$$\left(\frac{24}{T}\right)^2 = \left(\frac{12R}{3R}\right)^3$$

$T = 3 \text{ hour}$

12. The time period of a satellite in a circular orbit of radius R is T. The period of another satellite in a circular orbit of radius $9R$ is:

A. $3T$

B. $9T$

C. $27T$

D. $12T$

From kepler's law:

$$T^2 \propto R^3$$

So, $T_1 = T,\ R_1 = R,\ \ R_2 = 9R$

$$\Rightarrow \frac{T_1}{T_2} = \left(\frac{R_1}{R_2}\right)^{\frac{3}{2}}$$

$$\Rightarrow \frac{T_1}{T_2} = \left(\frac{R}{9R}\right)^{\frac{3}{2}}$$

$$\Rightarrow \frac{T}{T_2} = \frac{1}{27}$$

$$\Rightarrow T_2 = 27T$$

Hence, option (C) is the right choice.

13. The angular momentum of a planet of mass M moving around the sun in an elliptical orbit is $\vec{L}$. The magnitude of the areal velocity of the planet is :

A. $\frac{L}{M}$

B. $\frac{2L}{M}$

C. $\frac{L}{2M}$

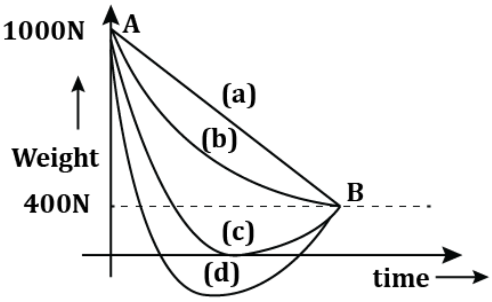
D. $\frac{4L}{M}$

We know that, magnitude of areal velocity of a planet is,

$$\frac{dA}{dt} = \frac{L}{2M}$$

Hence, option (C) is the correct answer.

14. A person whose mass is $100 \mathrm{~kg}$ travels from Earth to Mars in a spaceship. Neglect all other objects in sky and take acceleration due to gravity on the surface of the Earth and Mars as $10 \mathrm{~m/s}^2$ and $4 \mathrm{~m/s}^2$ respectively. Identify from the below figure, the curve that fits best for the weight of the passenger as a function of time.



A. (c)

B. (a)

C. (d)

D. (b)

While going from Earth to Mars, the weight of the person will go on decreasing as g_{net} decreases.

At neutral point, $g_{\text{net}} = 0$, so that the weight of the person is also equal to zero.

Also, after this neutral point, the weight again starts to increase, as g due to Mars goes on increasing.

Therefore, curve (c) best represent the weight of the passenger as a function of time.

Hence, option (A) is the correct answer.

15. A satellite is launched into a circular orbit of radius R around earth, while a second satellite is launched into a circular orbit of radius $1.02\ R$. The percentage difference in the time periods of the two satellites is :

A. 1.5

B. 2.0

C. 0.7

D. 3.0

Given:
$\Delta R = 1.02R - R = 0.02R$

Using Kepler's third law,

$T^2 \ \propto \ R^3$

$T = kR^{3/2} \qquad (k = \text{constant})$

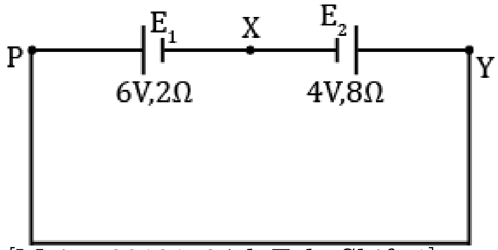
$$\frac{\Delta T}{T} = \frac{3}{2}\frac{\Delta R}{R}$$

$$\Rightarrow \frac{\Delta T}{T} = \frac{3}{2} \times 0.02 = 0.03$$

$$\%\ \text{Change in time period} = \frac{\Delta T}{T} \times 100 = 3\%$$

Hence, option (D) is correct.

16. A cell E_1 of emf $6 \mathrm{~V}$ and internal resistance 2Ω is connected with another cell E_2 of emf $4 \mathrm{~V}$ and internal resistance 8Ω as shown in the figure. The potential difference across points X and Y is



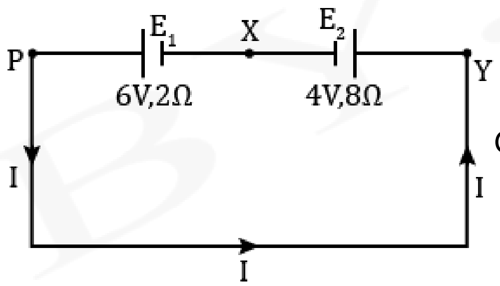
[Mains-20121, 24th Feb, Shift 1]

A. $3.6 \mathrm{~V}$

B. $10.0 \mathrm{~V}$

C. $5.6 \mathrm{~V}$

D. $2.0 \mathrm{~V}$



Given:

$E_1 = 6 \mathrm{~V}$
$r_1 = 2 \Omega$

$E_2 = 4 \mathrm{~V}$
$r_2 = 8 \Omega$

Now,
$E_{\text{eff}} = 6 - 4 = 2 \mathrm{~V}$
$R_{\text{eq}} = 2 + 8 = 10 \Omega$

So, current in the circuit will be

$$I = \frac{E_{\text{eff}}}{R_{\text{eq}}}$$

$$\Rightarrow I = \frac{2}{10} = 0.2 \mathrm{~A}$$

On going from point X to Y in clockwise, we get,

$$V_X + 4 + 0.2 \times 8 = V_Y$$

$$\Rightarrow V_X - V_Y = -5.6 \mathrm{~V}$$

Therefore, the potential difference across points X and Y is $5.6 \mathrm{~V}$.

17. A current through a wire depends on time as $i = \alpha_o t + \beta t^2$ where $\alpha_o = 20\ \mathrm{A/s}$ and $\beta = 8\ \mathrm{As^{-2}}$. Find the charge crossed through a section of the wire in $15\ \mathrm{s}$.

A. $2100\ \mathrm{C}$

B. $260\ \mathrm{C}$

C. $2250\ \mathrm{C}$

D. $11250\ \mathrm{C}$

Given :
$i = \alpha_o t + \beta t^2$
$\alpha_o = 20\ \mathrm{A/s}$
$\beta = 8\ \mathrm{As^{-2}}$
$t = 15\ \mathrm{s}$

We know that,

$$i = \frac{dq}{dt}$$

$$\Rightarrow \int_0^t i dt = \int_0^Q dq$$

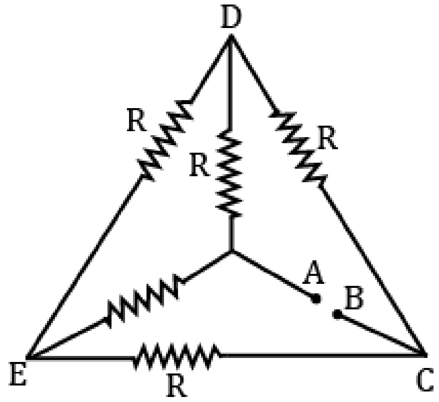
$$\Rightarrow \int_0^{15} (\alpha_o t + \beta t^2) dt = \int_0^Q dq$$

$$\Rightarrow Q = \left[\frac{\alpha_o t^2}{2} + \frac{\beta t^3}{3}\right]_0^{15}$$

$$\Rightarrow Q = \frac{20 \times 15^2}{2} + \frac{8 \times 15^3}{3} - (0+0)$$

$$\Rightarrow Q = 11250\ \mathrm{C}$$

18. Five equal resistances are connected in a network as shown in figure. The net resistance between the points A and B is



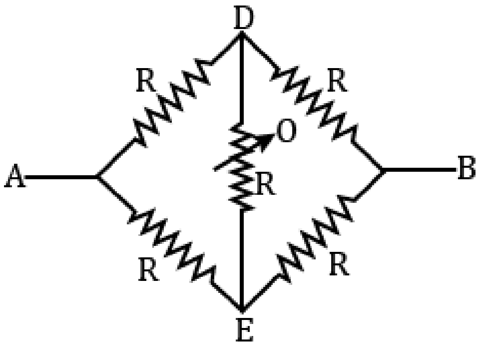
A. $\frac{3R}{2}$

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

C. R

D. $2R$

Redrawing the circuit we observe that it is a balanced wheatstone bridge .

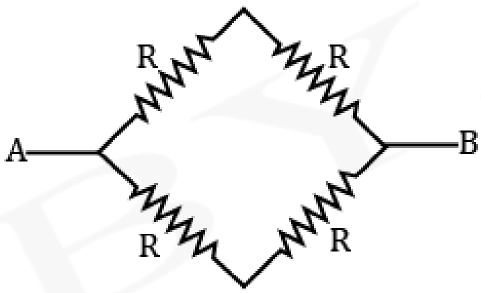


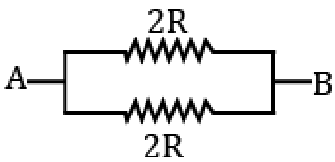
So, we know that ,

$R_1 R_4 = R_2 R_3$

$\frac{R_1}{R_2} = \frac{R_3}{R_4}$

If this condition satisfies then R_{DE} become redundant and here it satisfies the equations. Thus, R_{DE} is redundant.





$R_{eq} = \frac{2R \times 2R}{2R + 2R} = \frac{4R^2}{4R}$

$= R$

19. A resistor develops $500 \mathrm{~J}$ of thermal energy in $20 \mathrm{~s}$ when a current of $1.5 \mathrm{~A}$ is passed through it. If the current is increased from $1.5 \mathrm{~A}$ to $3 \mathrm{~A}$, what will be the energy developed in $20 \mathrm{~s}$.

A. $500 \mathrm{~J}$

B. $1000 \mathrm{~J}$

C. $2000 \mathrm{~J}$

D. $1500 \mathrm{~J}$

Thermal energy developed is given as:

$$H = I^2 R t$$

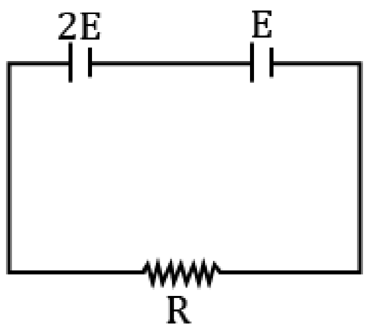
Time and resistor both are same, only current is changed.

$$\Rightarrow \frac{H_1}{H_2} = \left(\frac{I_1}{I_2}\right)^2$$

$$\Rightarrow \frac{500}{H_2} = \left(\frac{1.5}{3}\right)^2$$

$$\therefore H_2 = 500 \times \left(\frac{3}{1.5}\right)^2 = 2000 \mathrm{~J}$$

20. Two cells of emf $2E$ and E with internal resistance r_1 and r_2 respectively are connected in series to an external resistor R (see figure). The value of R, at which the potential difference across the terminals of the first cell becomes zero is



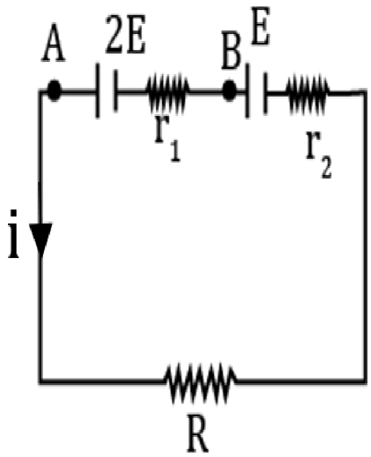
[Mains-2021, March 21st, Shift 2]

A. $r_1 - r_2$

B. $r_1 + r_2$

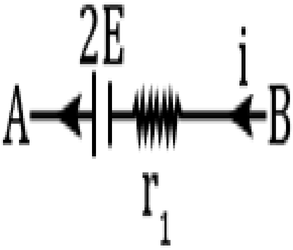
C. $\frac{r_1}{2} + r_2$

D. $\frac{r_1}{2} - r_2$ ✔



Current in the circuit, $i = \dfrac{3E}{R + r_1 + r_2}$

If potential difference across terminals of first cell is zero.



Then, $V_A - V_B = 0$

$\Rightarrow 2E - ir_1 = 0$

$\Rightarrow 2E = \dfrac{3E}{R + r_1 + r_2} r_1$

$\Rightarrow 2R + 2r_1 + 2r_2 = 3r_1$

$\therefore R = \dfrac{r_1}{2} - r_2$

21. A wire of $1\ \Omega$ has a length of $1\ \mathrm{m}$. It is stretched till its length increases by 25%. The percentage change in the resistance to the nearest integer is -

A. 25%

B. 12.5%

C. 76%

D. 56%

We know that,

$$R=\rho\frac{l}{A}$$

So,

$$\frac{R_1}{R_2}=\frac{l_1A_2}{A_1l_2}\quad\ldots(1)$$

Also, volume remain constant. So,

$$A_1l_1=A_2l_2$$

$$\Rightarrow\frac{A_2}{A_1}=\frac{l_1}{l_2}\quad\ldots(2)$$

From (1) and (2),

$$\frac{R_1}{R_2}=\frac{l_1^2}{l_2^2}$$

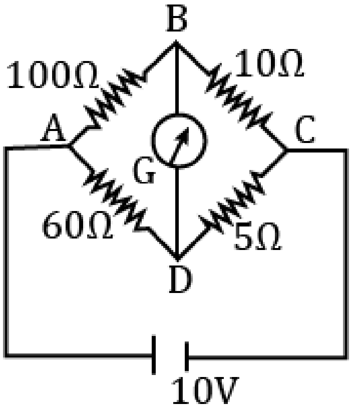
$$\Rightarrow\frac{1}{R_2}=\frac{(l)^2}{(1.25l)^2}$$

$$\Rightarrow R_2=1.5625\ \Omega$$

Hence, percentage change in the resistance,

$$=\frac{1.5625-1}{1}\times 100=56.25\%\approx 56\%$$

22. The four arms of a wheatstone bridge have resistances as shown in the figure. A galvanometer of $15\ \Omega$ resistance is connected across BD. Calculate the current through the galvanometer when a potential difference of $10\ \mathrm{V}$ is maintained across AC.

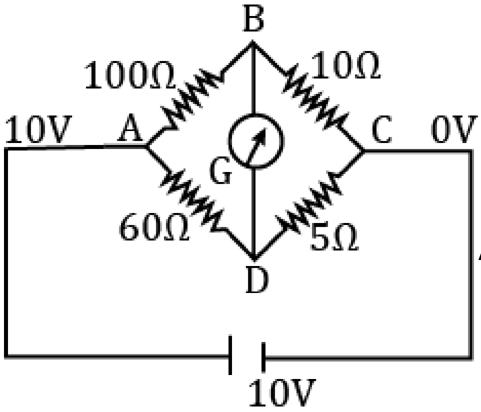


A. $4.87\ \mathrm{mA}$

B. $4.87\ \mu\mathrm{A}$

C. $2.44\ \mu\mathrm{A}$

D. $2.44\ \mathrm{mA}$



Applying KCL for point B:

$$\frac{V_B - 10}{100} + \frac{V_B - V_D}{15} + \frac{V_B - 0}{10} = 0$$

$$\frac{V_B - 10}{20} + \frac{V_B - V_D}{3} + \frac{V_B}{2} = 0$$

$$3V_B - 30 + 20V_B - 20V_D + 30V_B = 0$$

$53V_B - 20V_D = 30$ ....(1)

Similarly apllying KCL for point D:

$$\frac{V_D - 10}{60} + \frac{V_D - V_B}{15} + \frac{V_D - 0}{5} = 0$$

$$V_D - 10 + 4V_D - 4V_B + 12V_D = 0$$

$-4V_B + 17V_D = 10$ ....(2)

After solving equation (1) & (2):
$V_D = 0.792$ volt
$V_B = 0.865$ volt

Then the current through the galvanometer, $i = \dfrac{V_B - V_D}{R}$

$$i = \frac{0.865 - 0.792}{15}$$

$$i = 4.87 \text{ mA}$$

23. A current of $10\ \mathrm{A}$ exists in a wire of cross-sectional area $5\ \mathrm{mm}^2$. The drift velocity of the electrons is $2 \times 10^{-3}\ \mathrm{m/s}$. The number of free electrons in each cubic meter of the wire are :

A. 1×10^{23}

B. 2×10^{6}

C. 2×10^{25}

D. 625×10^{25}

Current through a wire is given by,

$$I = neAv_d$$

$$\Rightarrow n = \frac{I}{eAv_d}$$

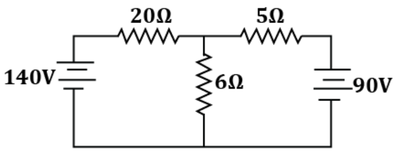
From the given data,

$$n = \frac{10}{1.6 \times 10^{-19} \times 5 \times 10^{-6} \times 2 \times 10^{-3}}$$

$$\Rightarrow n = 6.25 \times 10^{27} = 625 \times 10^{25}$$

Hence, option (D) is the correct answer.

24. The value of current in the $6\ \Omega$ resistor is :

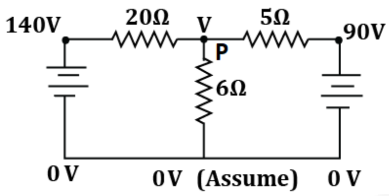


A. $4\ \mathrm{A}$

B. $8\ \mathrm{A}$

C. $10\ \mathrm{A}$

D. $6\ \mathrm{A}$



Applying KCL at point P,

$$\frac{V-0}{6}+\frac{V-90}{5}+\frac{V-140}{20}=0$$

$$\frac{10V+12V-1080+3V-420}{60}=0$$

$$\Rightarrow 10V+12V-1080+3V-420=0$$

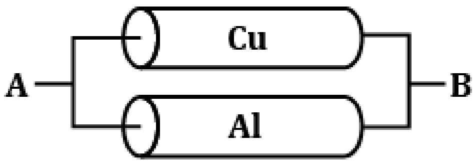
$$\Rightarrow V=60\ \text{Volts}$$

$\therefore$ Current in $6\ \Omega$ resistor,

$$i=\frac{V-0}{6}=\frac{60-0}{6}=10\ \mathrm{A}$$

Hence, option (C) is the correct answer.

25. A Copper (Cu) rod of length $25\ \mathrm{cm}$ and cross-sectional area $3\ \mathrm{mm}^2$ is joined with a similar Aluminium (Al) rod as shown in figure. Find the resistance of the combination between the ends A and B.
(Resistivity of Copper $= 1.7 \times 10^{-8}\ \Omega\mathrm{m}$
Resistivity of Aluminium $= 2.6 \times 10^{-8}\ \Omega\mathrm{m}$)



A. $2.170\ \mathrm{m}\Omega$

B. $1.429\ \mathrm{m}\Omega$

C. $0.0858\ \mathrm{m}\Omega$

D. $0.858\ \mathrm{m}\Omega$

Resistance of the combination be,

$$R = \frac{R_{\mathrm{Cu}} R_{\mathrm{Al}}}{R_{\mathrm{Cu}} + R_{\mathrm{Al}}}$$

As, $R = \frac{\rho l}{A}$, where ρ is the resistivity.

$$\Rightarrow R = \frac{l}{A} \frac{(\rho_{\mathrm{Cu}})(\rho_{\mathrm{Al}})}{\rho_{\mathrm{Cu}} + \rho_{\mathrm{Al}}}$$

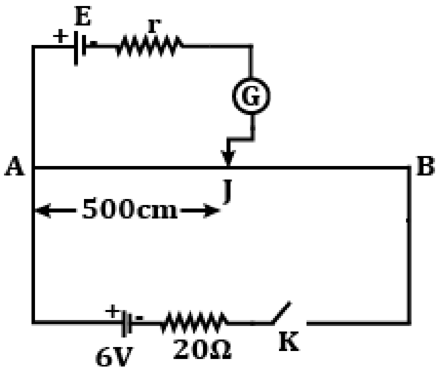
$$\Rightarrow R = \frac{25 \times 10^{-2}}{3 \times 10^{-6}} \times \frac{(1.7 \times 10^{-8})(2.6 \times 10^{-8})}{1.7 \times 10^{-8} + 2.6 \times 10^{-8}}$$

$$\Rightarrow R = \frac{25 \times 1.7 \times 2.6}{3 \times 4.3} \times 10^{-4}$$

$$\Rightarrow R = 8.58 \times 10^{-4}\ \Omega = 0.858\ \mathrm{m}\Omega$$

Hence, (D) is the correct answer.

26. In the given figure, there is a circuit of potentiometer of length $AB = 10\ \mathrm{m}$. The resistance per unit length is $0.1\ \Omega/\mathrm{cm}$. Across AB, a battery of emf E and internal resistance r is connected. The maximum value of emf, that can be measured, using this potentiometer is,



A. $5\ \mathrm{V}$

B. $2.25\ \mathrm{V}$

C. $6\ \mathrm{V}$

D. $2.75\ \mathrm{V}$

Maximum emf that can be measured by this potentiometer will be equal to potential drop across the entire potentiometer wire, i.e. wire AB.

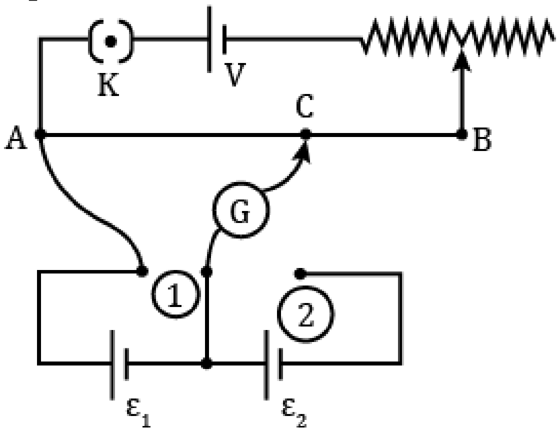
$$R_{AB} = 10 \times 0.1 \times 100 = 100\ \Omega$$

$$\therefore V_{AB} = I\ R_{AB} = \frac{E}{R_{AB} + r} \times R_{AB}$$

$$= \frac{6}{20 + 100} \times 100 = 5\ \mathrm{V}$$

Hence, (A) is the correct answer.

27. In the given potentiometer circuit arrangement, the balancing length AC is measured to be $250\ \mathrm{cm}$. When the galvanometer connection is shifted from point (1) to point (2) in the given diagram, the balancing length becomes $400\ \mathrm{cm}$. The ratio of the emf of two cells, $\frac{\mathcal{E}_1}{\mathcal{E}_2}$ is:



A. $\frac{5}{3}$

B. $\frac{8}{5}$

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

D. $\frac{3}{2}$

According to the working of potentiometer,

At position (1),

$\mathcal{E}_1 = kl_1 \ldots . (i)$

At position (2),

$\mathcal{E}_1 + \mathcal{E}_2 = kl_2 \ldots . (ii)$

$$\frac{(i)}{(ii)}$$

$$\Rightarrow \frac{\mathcal{E}_1}{\mathcal{E}_1 + \mathcal{E}_2} = \frac{l_1}{l_2} = \frac{250}{400} = \frac{5}{8}$$

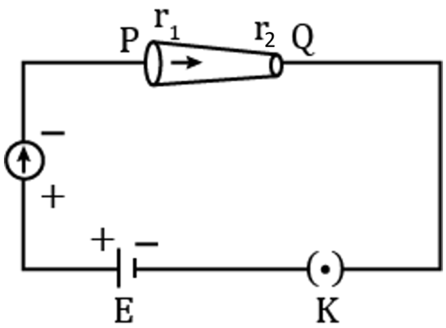
$$\Rightarrow 8\mathcal{E}_1 = 5\mathcal{E}_1 + 5\mathcal{E}_2$$

$$\Rightarrow 3\mathcal{E}_1 = 5\mathcal{E}_2$$

$$\Rightarrow \frac{\mathcal{E}_1}{\mathcal{E}_2} = \frac{5}{3}$$

Hence, option (A) is correct.

28. In the given figure, a battery of emf E is connected across a conductor PQ of length $'l'$ and different area of cross-sections having radii r_1 and r_2 $(r_2 < r_1)$.



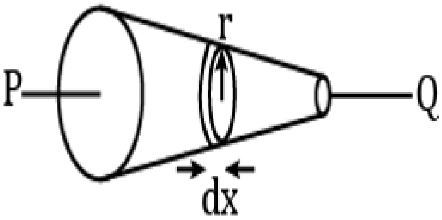
Choose the correct option as one moves from P to Q :

A. Drift velocity of electron increases.

B. Electric field decreases.

C. Electron current decreases

D. All of these



Take an elementary disc of radius r and thickness dx in conductor.

Resistance of element, $dR = \frac{\rho dx}{\pi r^2}$

Current is constant in conductor,

$\therefore i =$ constant

So, the potential drop across thickness dx will be,

$$dV = idR = \frac{i\rho dx}{\pi r^2}$$

Electric field in the conductor will be,

$$E_{field} = \frac{dV}{dx} = \frac{i\rho}{\pi r^2}$$

$$\therefore \ E_{field} \propto \frac{1}{r^2}$$

And drift velocity will be,

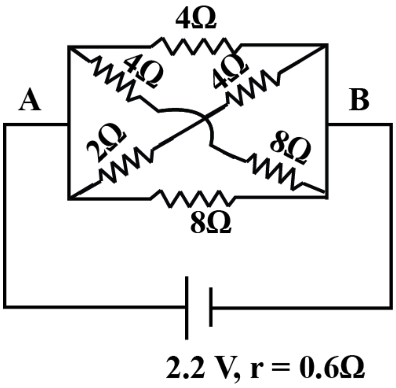
$$v_d = \frac{e\ E_{field}\ \tau}{m}$$

$$\therefore v_d \ \propto E_{field} \propto \ \frac{1}{r^2}$$

From above expression, we can say that, If r decreases, E_{field} & v_d will increase.

$\therefore$ option (A) is correct.

29. In the given figure, the emf of the cell is $2.2\ V$ and if internal resistance is $0.6\ \Omega$. Calculate the power dissipated in the whole circuit.



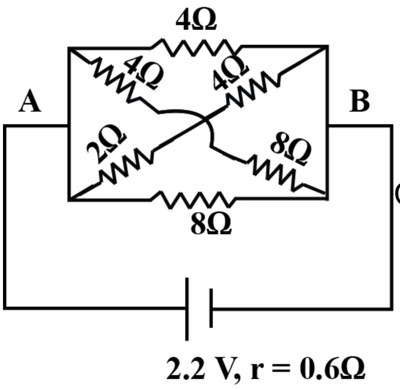
A. 2.2 W

B. 4.4 W

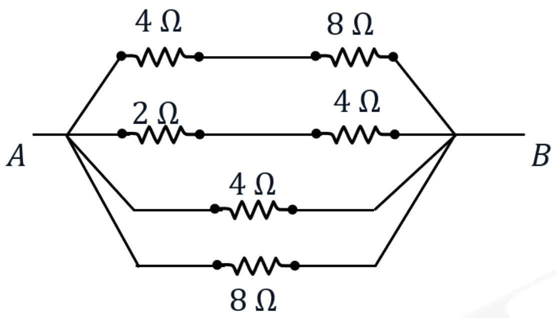
C. 0.65 W

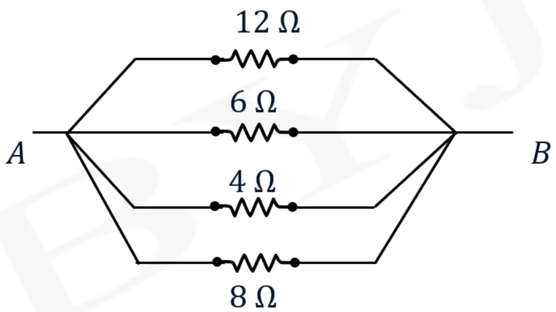
D. 1.32 W

Given circuit is



Considering the arrangement of resistors given, the equivalent resistance is given by





$$\frac{1}{R_{eq}}=\frac{1}{12}+\frac{1}{6}+\frac{1}{4}+\frac{1}{8}=\frac{2+4+6+3}{24}$$

$$=\frac{15}{24}=\frac{5}{8}$$

$\Rightarrow \quad R_{eq}=1.6\ \Omega$

Therefore, total current in the ciruit is given by

$$I=\frac{\epsilon}{R_{eq}+r}=\frac{2.2}{1.6+0.6}=1\text{ A}$$

Thus, power dissipated in the whole circuit is given as

$P=V\times I=2.2\times 1=2.2\text{ W}$

Hence, option (A) is the right answer.

30. What equal length of an iron wire and a copper-nickel alloy wire, each of $2 \mathrm{~mm}$ diameter connected parallel to give an equivalent resistance of 3Ω ?
(Given resistivities of iron and copper-nickel alloy wire are $12 \mu \Omega \mathrm{~cm}$ and $51 \mu \Omega \mathrm{~cm}$ respectively)

A. $110 \mathrm{~m}$

B. $97 \mathrm{~m}$

C. $90 \mathrm{~m}$

D. $82 \mathrm{~m}$

In the question the diameter and length of both the wires is same, and they are connected parallel to each other. Then, the effective resistance can be calculated as,

Using, $R=\rho \frac{l}{A}$

$$R=\frac{\left(\rho_1 \rho_2\right) \frac{l^2}{A^2}}{\left(\rho_1+\rho_2\right) \frac{l}{A}}$$

i.e. $3=\frac{12 \times 51}{12+51} \frac{l}{A}$

So we get the required length of the wires as,

$$l=3 \times \frac{63 \times \pi \times(1)^2 \times 10^{-6}}{612}$$

This gives $l=97 \mathrm{~m}$