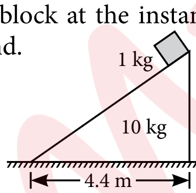
PRACTICE PAPER

PHYSICS

1. Four charges q_1, q_2, q_3 and q_4 of same magnitude are fixed along the x-axis at $x = -2a, -a, +a$ and $+2a$ respectively. A positive charge of 3 μC is placed on the positive y-axis at a distance $r > 0$. Direction of net electric force on charge 3 μC will be along $-x$ direction if
(a) q_1, q_2, q_3 and q_4 are all positive
(b) q_1 and q_2 are positive but q_3 and q_4 are negative
(c) q_1 and q_4 are positive but q_2 and q_3 are negative
(d) q_1 and q_3 are positive but q_2 and q_4 are negative.

2. If 9.8 m/s^2 is the acceleration due to gravity on the earth's surface, the gain in potential energy of an object of mass 2 kg raised from the surface of the earth to a height equal to the radius of earth is (radius of earth is 6400 km)
(a) 6.27×10^7 J (b) 1.25×10^8 J
(c) 3.14×10^7 J (d) 5.0×10^8 J

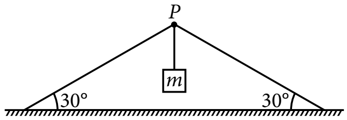
3. A block of mass 1 kg is placed on the top of a bigger block of mass 10 kg as shown in figure. All the surfaces are frictionless. The system is released from rest. Find the distance moved by the bigger block at the instant the smaller block reaches the ground.
(a) 0.80 m
(b) 2.2 m
(c) 4.4 m
(d) 0.44 m



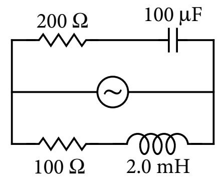
4. Which of the following statements is/are correct?
I. For practical purposes, the earth is used as a reference at zero potential in electrical circuits.
II. The electrical potential of a sphere of radius R with charge Q uniformly distributed on the surface is given by $\dfrac{Q}{4\pi\varepsilon_0 R}$.
III. Work done in carrying a point charge from one point to another in an electrostatic field depends on the path along which the point charge is carried.
(a) I and II only (b) II only
(c) III only (d) I, II and III.

5. Four persons A, B, C and D initially at the four corners of a square of side 10 m. Each person now moves with a uniform speed 20 m/s in such a way that A always moves directly towards B, B directly towards C, C directly towards D and D directly towards A. The four persons will meet after a time
(a) 2 s (b) 4 s (c) 5 s (d) 10 s

6. Two identical ladders are arranged as shown in the figure. Mass of each ladder is 10 kg and length 5 m. A block of mass m hangs from point P. If the system is in equilibrium, then find the magnitude of frictional force acting on the base of the ladder. (m = 5 kg, g = 10 m/s^2)
(a) 130 N
(b) 260 N
(d) 6.5 N
(d) 10 N



7. Find the rms current drawn from an AC source of 50 V (rms) when
(i) frequency is very large
(ii) frequency is very small.
(a) (i) 0.25 A (ii) 0.5 A
(b) (i) 0.2 A (ii) 0.4 A
(c) (i) 0.5 A (ii) 0.25 A
(d) (i) 0.5 A (ii) 1.0 A



8. A spring of force constant k is cut into two pieces such that one piece is five times the length of the other. Then, the longer piece will have a force constant of
(a) $\dfrac{k}{5}$ (b) $5k$ (c) $\dfrac{6k}{5}$ (d) $\dfrac{5k}{6}$

9. The radius of uniform solid sphere is measured to be (6.50 ± 0.20) cm, and its mass is measured to be (1.85 ± 0.02) kg. Find the density of the sphere.
(a) $(1.61 \pm 0.20) \times 10^3$ kg/m^3
(b) $(1.60 \pm 0.22) \times 10^3$ kg/m^3
(c) $(1.61 \pm 0.17) \times 10^3$ kg/m^3
(d) $(1.60 \pm 0.17) \times 10^3$ kg/m^3

10. Photons of wavelength λ are incident on a metal. The most energetic photoelectrons ejected from the metal are bent into a circular arc of radius R by a uniform magnetic field of magnitude B. Find the work function of metal.
(a) $\dfrac{hc}{\lambda} - \dfrac{e^2B^2R^2}{m_e}$ (b) $\dfrac{hc}{\lambda} + \dfrac{e^2B^2R^2}{2m_e}$
(c) $\dfrac{hc}{\lambda} - \dfrac{e^2B^2R^2}{3m_e}$ (d) $\dfrac{hc}{\lambda} - \dfrac{e^2B^2R^2}{2m_e}$

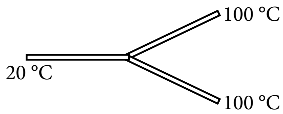
11. A cubical block of mass m and edge l floats in a liquid of density ρ. If it is given a small vertical displacement from equilibrium so that it undergoes oscillation with a time period
(a) $2\pi\sqrt{\dfrac{a}{g}}$ (b) $2\pi\sqrt{\dfrac{m}{\rho g}}$
(c) $\pi\sqrt{\dfrac{a}{g}}$ (d) $\pi\sqrt{\dfrac{m}{\rho g}}$

12. A standing wave pattern is set up by electromagnetic waves between two metal sheets 3.0 m apart, which is the shortest distance between the plates that produces standing wave pattern. Find the frequency of electromagnetic waves. (Speed of electromagnetic wave = 3×10^8 m/s)

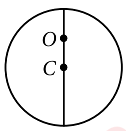
(a) 75 MHz (b) 50 MHz
(c) 25 MHz (b) 100 MHz

13. Two identical vessels with their bases at the same level each contain liquid of density 1050 kg/m^3. The height of the liquid in one vessel is 2.0 m and in the other is 1.50 m. The cross-sectional area of each vessel is 1.5 m^2. Find the work done by gravity in equalising the levels when vessels are connected.
(a) 600 J (b) 900 J (c) 840 J (d) 965 J

14. Three rods made of same material and having the same cross-section have been joined as shown in the figure. Each rod is of the same length. The left and right ends are kept at 20°C and 100°C respectively. The temperature of junction of the three rods will be
(a) 73°C
(b) 60°C
(c) 50°C
(d) 80°C

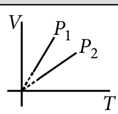
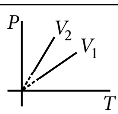
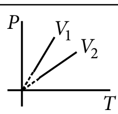
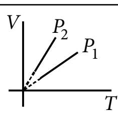


15. There is a small air bubble inside a glass sphere (μ = 1.5) of radius 20 cm. The bubble is 8.0 cm below the surface and is viewed normally from the outside as shown in the figure. What is the apparent depth of the bubble?
(a) 6.15 cm above the surface.
(b) 6.15 cm below the surface.
(c) 3.5 cm below the surface.
(d) 3.5 cm above the surface.



16. A material having refractive index 1.40 is used as an antireflecting coating on a piece of glass (μ = 1.50). What should minimum thickness of this film be to minimize reflection of 560 nm light?
(a) 93 nm (b) 186 nm
(c) 100 nm (d) 200 nm

17. Match the following.

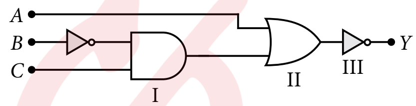
	Column I		Column II
A.		p.	isobar ($P_1 > P_2$)
B.		q.	isobar ($P_1 < P_2$)
C.		r.	isochor ($V_1 > V_2$)
D.		s.	isochor ($V_1 < V_2$)

	A	B	C	D
(a)	p	q	r	s
(b)	q	s	r	p
(c)	s	q	r	p
(d)	q	s	p	r

18. The activity of a radioactive sample is measured as N_0 counts per minute at t = 0 and N_0/e counts per minute at t = 5 minutes. The time (in minutes) at which the activity reduces to half its value is
(a) $\log_e \frac{2}{5}$ (b) $\frac{5}{\log_e 2}$
(c) $5\log_{10} 2$ (d) $5\log_e 2$

19. A radio transmitter operates at a frequency of 880 kHz and a power of 10 kW. The number of photons emitted per second are
(a) 1.7×10^{31} (b) 1327×10^{34}
(c) 13.27×10^{34} (d) 0.075×10^{-34}

20. The output Y of the logic circuit shown in figure is represented as



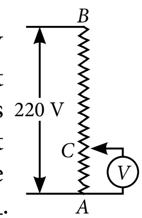
(a) $\overline{A} + \overline{B \cdot C}$ (b) $A + \overline{B} \cdot C$
(c) $\overline{A + B \cdot C}$ (d) $\overline{A + \overline{B} \cdot C}$

Numerical Value Type

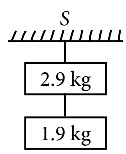
21. The photoelectric work function of a metal is 1 eV. Light of wavelength 3000 Å falls on it. Then the velocity with which the photoelectrons come out of the metal is $x \times 10^6$ m s^{-1} where the value of x is ________.

22. A bird of mass 1.23 kg is able to hover by imparting a downward velocity of 10 m s^{-1} uniformly to air of density ρ kg m^{-3} over an effective area 0.1 m^2. If the acceleration due to gravity is 10 m s^{-2}, then the magnitude of ρ (in kg m^{-3}) is ________.

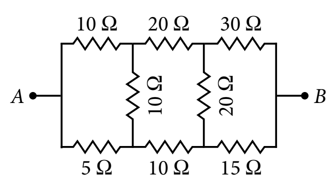
23. A potential difference of 220 V is maintained across a 12000 ohm rheostat AB as shown in figure The voltmeter V has a resistance of 6000 ohm and point C is at one fourth of the distance from A to B. The reading in the voltmeter (in V) is ________.



24. Two blocks of masses 2.9 kg and 1.9 kg are suspended from a rigid support S by two inextensible wires each of length 1 m. The upper wire has negligible mass and the lower wire has a uniform mass of 0.2 kg/m. The whole system of blocks have an upward acceleration of 0.2 m s^{-2}. The tension (in N) at the midpoint of upper wire is ________.
(Given : g = 9.8 m s^{-2}).



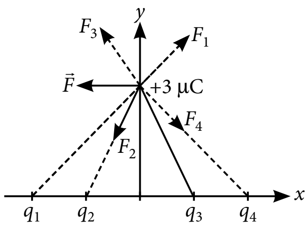
25. In the given figure, the equivalent resistance (in Ω) between A and B is ________.



HINTS & EXPLANATIONS

PHYSICS

1. (d) : In magnitude, $F_2 = F_3$ and $F_1 = F_4$
Resultant of F_2 and F_3 will be along $-x$ direction, while resultant of F_1 and F_4 will be along $+x$ direction.
But resultant of F_2 and F_3 is larger than that of F_1 and F_4.
Hence, direction of net electric force will be along $-x$ direction.



2. (a) : $\Delta U = \dfrac{mgh}{1+\left(\dfrac{h}{R}\right)}$

Given, $h = R$, $\Delta U = \dfrac{mgR}{1+\left(\dfrac{R}{R}\right)}$

$\Delta U = \dfrac{1}{2}mgR = \dfrac{1}{2}\times 2\times 9.8\times 6400\times 10^3$

$\Delta U = 6.272 \times 10^7$ J

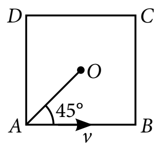
3. (d) : If the bigger block moves towards right by a distance x, then the smaller block will move towards left by a distance $(4.4 - x)$ m.
As there is no external force on the system then the centre of mass lies on same position.

$1 \times (4.4 - x)$ m $= 10x$

$4.4 = 11x \Rightarrow x = 0.44$ m

4. (a) : Electric field is conservative in nature. So, work done in this field depends on the initial and final positions of charge.

5. (c) : By symmetry, all the persons will meet at the centre of the square.
Let a be the side of the square, then,



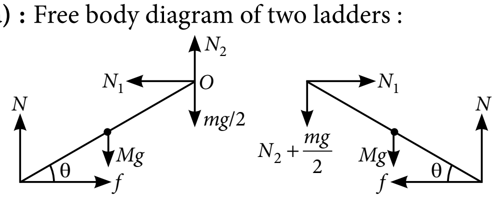
$AO = \dfrac{a\sqrt{2}}{2} = \dfrac{a}{\sqrt{2}}$

Component of velocity along AO is

$v\cos 45° = \dfrac{v}{\sqrt{2}}$

Time taken $= \dfrac{a/\sqrt{2}}{v/\sqrt{2}} = \dfrac{a}{v} = \dfrac{10}{2} = 5$ s

6. (a) : Free body diagram of two ladders :



System is in equilibrium, so net force on it is zero, also net torque about point O is zero.

Now, $\Sigma F_x = 0 \Rightarrow N_1 = f$ ...(i)

$\Sigma F_y = 0 \Rightarrow N + N_2 = Mg + \dfrac{mg}{2}$ ...(ii)

$N = N_2 + Mg + \dfrac{mg}{2}$ ...(iii)

Balancing torque about O,

and $Mg\dfrac{L}{2}\cos\theta + fL\sin\theta = NL\cos\theta$

or $\dfrac{Mg}{2}\cos\theta + f\sin\theta = N\cos\theta$ ...(iv)

From eqn. (ii) and (iii), we get $N = Mg + \dfrac{mg}{2}$

$f\sin\theta = \left(\dfrac{M+m}{2}\right)g\cos\theta$ (Using (iv))

$\Rightarrow f = \left(\dfrac{M+m}{2}\right)g\cot\theta$

$\Rightarrow f = \dfrac{10+5}{2}\times 10\times \cot 30° \approx 130$ N

7. (a) : (i) When ωL is very large, Z is large for lower branch so current through it negligible.

Also, $\dfrac{1}{\omega C}$ will be negligible compared to R for the upper branch, so current in upper branch

$I = \dfrac{\varepsilon}{Z} \approx \dfrac{\varepsilon}{R} = \dfrac{50}{200} = 0.25$ A

(ii) Now, $\dfrac{1}{\omega C}$ is very large in the upper branch and ωL is very small compared to R in the lower branch. Current in lower branch

$I = \dfrac{V}{Z} \approx \dfrac{V}{R} = \dfrac{50}{100} = 0.5$ A

8. (c) : For a spring, $l_1k_1 = l_2k_2 = lk$
As per question $l_1 : l_2 = 1 : 5$

$l_2 = 5l_1 \therefore l_1k_1 = 5l_1k_2 \Rightarrow k_2 = k_1/5$

Also, $l_1 + l_2 = l$

$\dfrac{kl}{k_1} + \dfrac{kl}{k_2} = l \Rightarrow \dfrac{k}{k_1} + \dfrac{5k}{k_1} = 1 \Rightarrow \dfrac{6k}{k_1} = 1$

$\Rightarrow k_1 = 6k \therefore k_2 = 6k/5$

9. (c) : Here, $r = (6.50 \pm 0.20) \times 10^{-2}$ m
$m = (1.85 \pm 0.02)$ kg

$\rho = \dfrac{m}{\left(\dfrac{4}{3}\right)\pi r^3}$

$\dfrac{\Delta\rho}{\rho} = \dfrac{\Delta m}{m} + \dfrac{3\Delta r}{r} \Rightarrow \dfrac{\Delta\rho}{\rho} = \dfrac{0.02}{1.85} + \dfrac{3(0.20)}{6.50} = 0.103$

$\rho = \dfrac{1.85}{\left(\dfrac{4}{3}\right)\pi(6.5\times 10^{-2})^3} = 1.61 \times 10^3$ kg/m^3

$\Delta\rho = (1.61 \times 10^3) \times 0.103 \approx 0.17 \times 10^3$ kg/m^3

$\rho + \Delta\rho = (1.61 \pm 0.17) \times 10^3$ kg/m^3

10. (d) : For electron in circular orbit in a magnetic field,

Centripetal force, $qvB = \dfrac{m_e v^2}{R}$ or $m_e v = eBR$

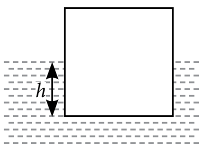
$$K_{max} = \frac{1}{2}mv^2 = \frac{p^2}{2m_e} = \frac{e^2B^2R^2}{2m_e}$$

From Einstein's photoelectric equation,

$$K_{max} = \frac{hc}{\lambda} - \phi$$

$$\phi = \frac{hc}{\lambda} - K_{max} = \frac{hc}{\lambda} - \frac{e^2B^2R^2}{2m_e}$$

11. (a) : Let h be the length of block immersed in liquid as shown in figure.



When block is floating,

$mg = Ah\rho g$

If the block is given vertical displacement y then the effective restoring force is

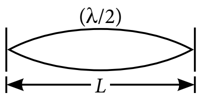
$F = -[A(h + y)\rho g - mg] = -[A(h + y)\rho g - Ah\rho g] = -A\rho gy$

$F \propto -y$ *i.e.*, it follows SHM,

$$\therefore \quad T = 2\pi\sqrt{\frac{m}{A\rho g}} = 2\pi\sqrt{\frac{\rho a^3}{a^2\rho g}} = 2\pi\sqrt{\frac{a}{g}}$$

12. (b) : In fundamental mode,

$$\frac{\lambda}{2} = L \Rightarrow \lambda = 2L$$

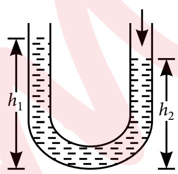


$\lambda = 2 \times 3 = 6$ m

Frequency of wave, $\upsilon = \frac{c}{\lambda}$

$$\upsilon = \frac{3\times10^8}{6} = 0.5 \times 10^8 \text{ Hz} = 50 \text{ MHz}$$

13. (d) : Let h be level in equilibrium.

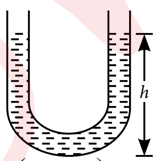


As volume of water remains same so,

$Ah_1 + Ah_2 = 2Ah$

$$h = \frac{h_1 + h_2}{2}$$

Work done by gravity = $U_i - U_f$



$$= \left(m_1g\frac{h_1}{2} + m_2g\frac{h_2}{2}\right) - (m_1 + m_2)g\frac{h}{2}$$

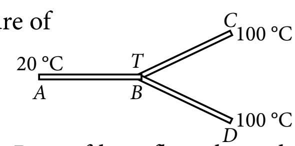
$$= \frac{Ah_1\rho gh_1}{2} + \frac{Ah_2\rho gh_2}{2} - (Ah_1\rho + Ah_2\rho)g\left(\frac{h_1 + h_2}{4}\right)$$

$$W = \frac{\rho Ag}{4}[2h_1^2 + 2h_2^2 - (h_1 + h_2)(h_1 + h_2)]$$

$$= \frac{\rho Ag}{4}(h_1 - h_2)^2 = \frac{1050\times1.5\times9.8}{4}(2.0 - 1.5)^2$$

$W = 965$ J

14. (a) : Let T be the temperature of the junction.



Thermal resistance of all the three rods is equal.

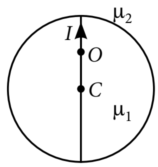
Rate of heat flow through BD + Rate of heat flow through BC = Rate of heat flow through AB

$$\frac{100 - T}{l} + \frac{100 - T}{l} = \frac{T - 20}{l}$$

where l is the length of each rod.

$200 - 2T = T - 20 \Rightarrow 3T = 220°C$ or $T = \frac{220}{3} = 73°C$

15. (b) : Here $u = -8$ cm



$R = -20$ cm, $\mu_1 = 1.5$, $\mu_2 = 1$

Using refraction formula,

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\Rightarrow \frac{1}{v} - \frac{1.5}{-8} = \frac{1 - 1.5}{-20} \Rightarrow \frac{1}{v} + \frac{1.5}{8} = \frac{0.5}{20} = \frac{1}{40}$$

$$\frac{1}{v} = \frac{1}{40} - \frac{1.5}{8} = \frac{1 - 7.5}{40} = \frac{-6.5}{40} \Rightarrow v = -6.15 \text{ cm}$$

$\therefore$ Bubble will be 6.15 cm below the surface.

16. (c) : There will be two phase reversals caused by reflection, one at top and one at the bottom surface of coating.

$\therefore$ For destructive infereance,

$$2\mu t = \left(m + \frac{1}{2}\right)\lambda \Rightarrow t = \left(m + \frac{1}{2}\right)\frac{\lambda}{2\mu}$$

For minimum thickness of the film, $m = 0$

$$\therefore \quad t = \frac{1}{2}\times\frac{560 \text{ nm}}{2\times1.4} = 100 \text{ nm}$$

17. (b) : A - q ; B - s ; C - r ; D - p

18. (d) : According to activity law

$R = R_0e^{-\lambda t}$ ...(i)

where, R_0 = initial activity at $t = 0$

R = activity at time t, λ = decay constant

According to given problem,

$R_0 = N_0$ counts per minute

$R = N_0/e$ counts per minute at $t = 5$ minutes

Substituting these values in equation (i), we get

$$\frac{N_0}{e} = N_0e^{-5\lambda}$$

$e^{-1} = e^{-5\lambda}$

$5\lambda = 1$ or $\lambda = \frac{1}{5}$ per minute

At $t = T_{1/2}$, the activity R reduces to $\frac{R_0}{2}$.

where $T_{1/2}$ = half life of a radioactive sample.

From equation (i), we get

$$\frac{R_0}{2} = R_0e^{-\lambda T_{1/2}}$$

$e^{\lambda T_{1/2}} = 2$

Taking natural logarithms of both sides of above equation, we get

$\lambda T_{1/2} = \log_e 2$

$$\text{or} \quad T_{1/2} = \frac{\log_e 2}{\lambda} = \frac{\log_e 2}{\left(\frac{1}{5}\right)} = 5\log_e 2 \text{ minutes}$$

19. (a) : Power = $nh\upsilon$

$$\text{or} \quad n = \frac{\text{Power}}{h\upsilon} = \frac{10\times10^3}{6.6\times10^{-34}\times880\times10^3} = \frac{10^{34}}{6.6\times88}$$

or $n = 1.7 \times 10^{-3} \times 10^{34} = 1.7 \times 10^{31}$

20. (d) : At logic gate I, the Boolean expression is

$Y' = \overline{B} \cdot C$

At logic gate II, the Boolean expression is

$Y'' = A + (\overline{B} \cdot C)$

At logic gate III, the Boolean expression is

$Y = \overline{A + (\overline{B} \cdot C)}$

21. (1) : Incident energy $E = h\upsilon = \dfrac{hc}{\lambda}$

or $E(\text{in eV}) = \dfrac{12400}{\lambda(\text{Å})}(\text{eV Å}) = \dfrac{12400(\text{eV Å})}{3000(\text{Å})} = 4.13 \text{ eV}$

According to Einstein's photoelectric equation,
Incident energy = work function + kinetic energy of emitted photoelectrons

$h\upsilon = \phi_0 + K$ or $K = h\upsilon - \phi_0 = 4.13 - 1 = 3.13 \text{ eV}$

or $\dfrac{1}{2}mv^2 = 3.13 \times 1.6 \times 10^{-19}$

or $v^2 = \dfrac{3.13 \times 1.6 \times 10^{-19} \times 2}{9.1 \times 10^{-31}}$ or $v = 1 \times 10^6 \text{ m s}^{-1}$

22. (1.23) : If the wings of the bird sweeps out a mass δm of air in time δt, then the upward force exerted on the bird is

$$F = u\frac{\delta m}{\delta t} = u\frac{\delta m}{\delta x} \times \frac{\delta x}{\delta t} = u^2 \frac{\delta m}{\delta x} \qquad \left(\because\ u = \frac{\delta x}{\delta t}\right)$$

where $F = mg$ and u is the downward velocity.
Force per unit area is

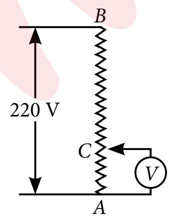
$$\frac{F}{A} = u^2 \frac{\delta m}{A\delta x} = u^2 \times \frac{\text{mass swept}}{\text{volume swept}} = u^2 \times \rho$$

or $\dfrac{mg}{A} = \rho u^2$

or $\rho = \dfrac{mg}{Au^2} = \dfrac{1.23 \times 10}{0.1 \times (10)^2} = 1.23 \text{ kg m}^{-3}$

23. (40) : As in case of linear rheostat, $R \propto$ length L

$\therefore \dfrac{R_{AC}}{R_{AB}} = \dfrac{AC}{AB}$



Here, $R_{AB} = 12000\ \Omega$

and $AC = \dfrac{1}{4}AB$

$\therefore R_{AC} = 12000 \times \dfrac{1}{4} = 3000\ \Omega$

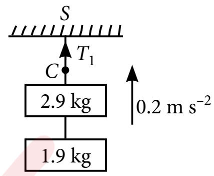
As the resistance R_{AC} (= 3000 Ω) is in parallel with voltmeter of resistance 6000 Ω. Therefore, the effective resistance between points A and C will be

$$R'_{AC} = \frac{3000 \times 6000}{(3000 + 6000)} = 2000\ \Omega$$

For resistance between points B and C, R_{BC} and R'_{AC} are in series. Therefore, the voltmeter reading will be

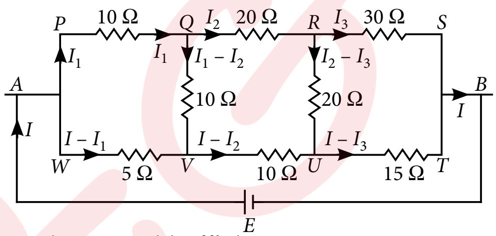
$$V_{AC} = \frac{R'_{AC}}{(R_{BC} + R'_{AC})}V_{AB} = \frac{2000}{(9000 + 2000)} \times 220 = 40 \text{ V}$$

24. (50) : Applying Newton's second law of motion,



$T_1 - (2.9 + 0.2 + 1.9)\,9.8$
$= (2.9 + 0.2 + 1.9)\,0.2$
$T_1 = 49 + 1 = 50$ N

25. (20) :



Applying Kirchhoff's law,
For loop $PQVWP$:

$10I_1 + 10(I_1 - I_2) - 5(I - I_1) = 0 \Rightarrow 5I_1 - 2I_2 = I$ ...(i)

For loop $QRUVQ$:

$20I_2 + 20(I_2 - I_3) - 10(I_1 - I_2) - 10(I - I_2) = 0$

$\Rightarrow 6I_2 - 2I_3 - I_1 = I$ ...(ii)

For loop $RSTUR$:

$30I_3 - 20(I_2 - I_3) - 15(I - I_3) = 0 \Rightarrow 13I_3 - 4I_2 = 3I$ ...(iii)

For loop $AWVUTBA$:

$5(I - I_1) + 10(I - I_2) + 15(I - I_3) = E$

$\Rightarrow 30I - 5I_1 - 10I_2 - 15I_3 = E$ ...(iv)

Solving equation (i), (ii) and (iii), we get

$I_1 = I/3$, $I_2 = I/3$ and $I_3 = I/3$

From (iv),

$30I - \dfrac{5}{3}I - \dfrac{10}{3}I - \dfrac{15}{3}I = IR_{eq}$ (Ohm's law)

$\Rightarrow 20\,I = I\,R_{eq} \Rightarrow R_{eq} = 20\ \Omega.$