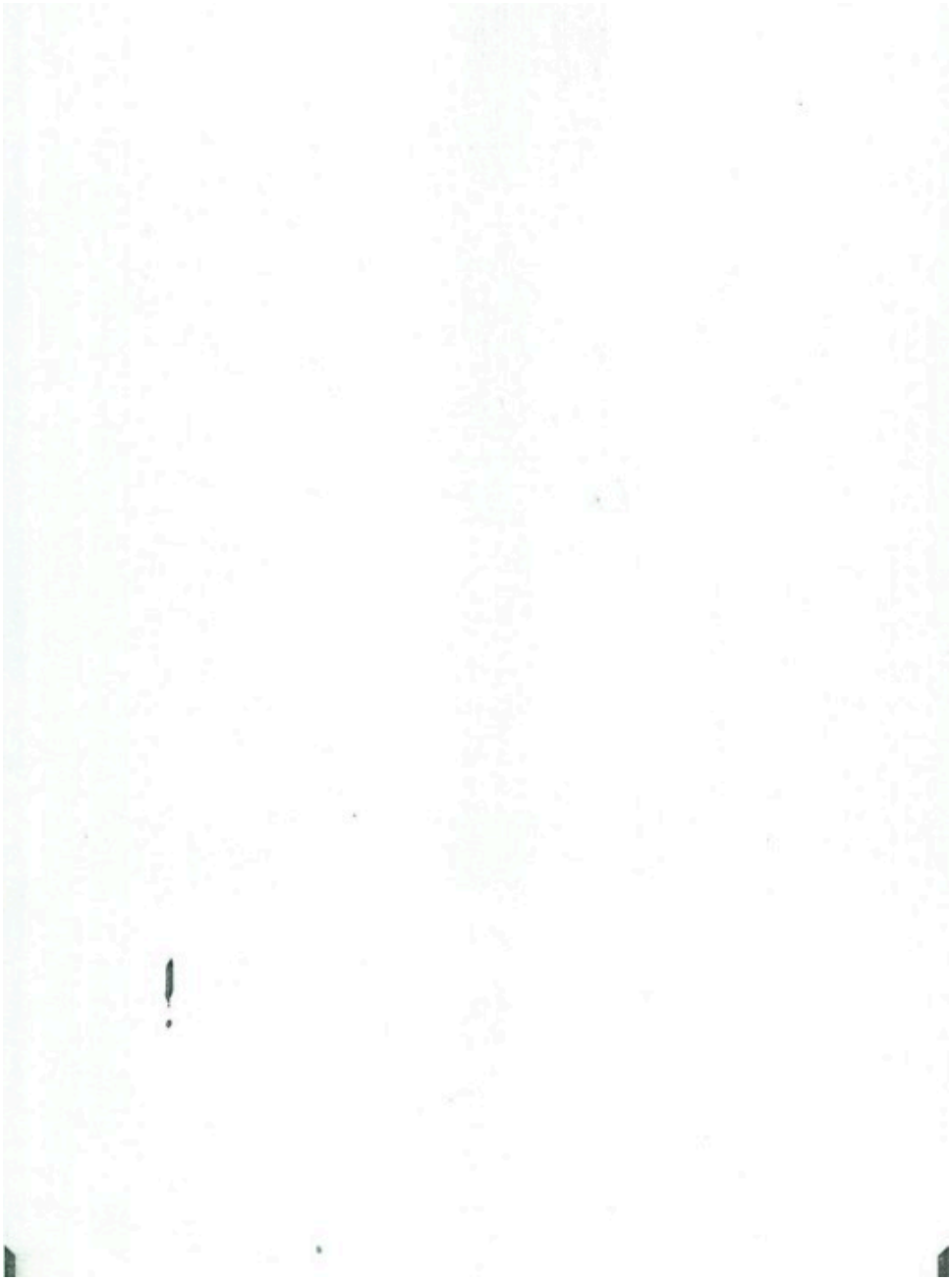
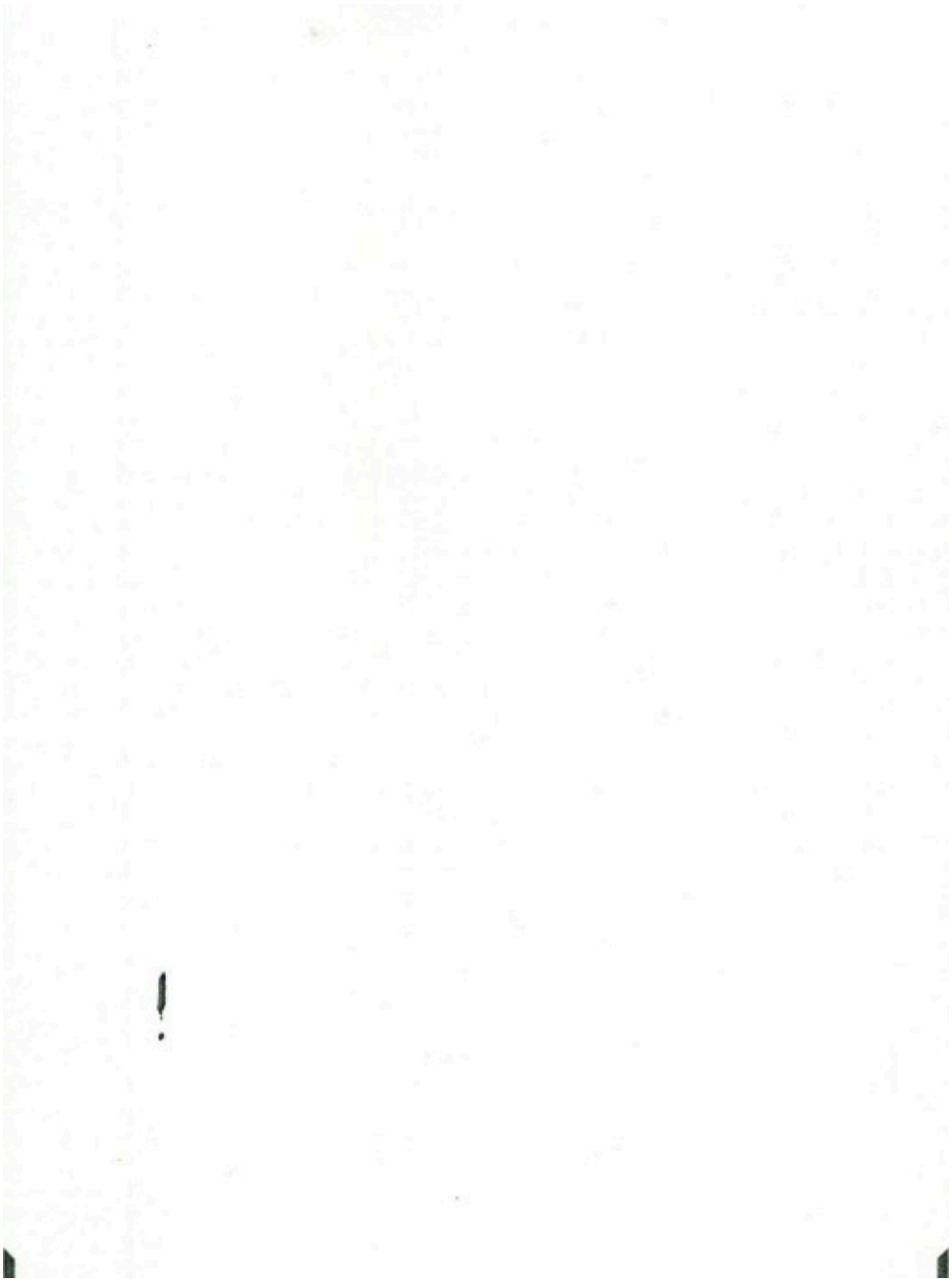
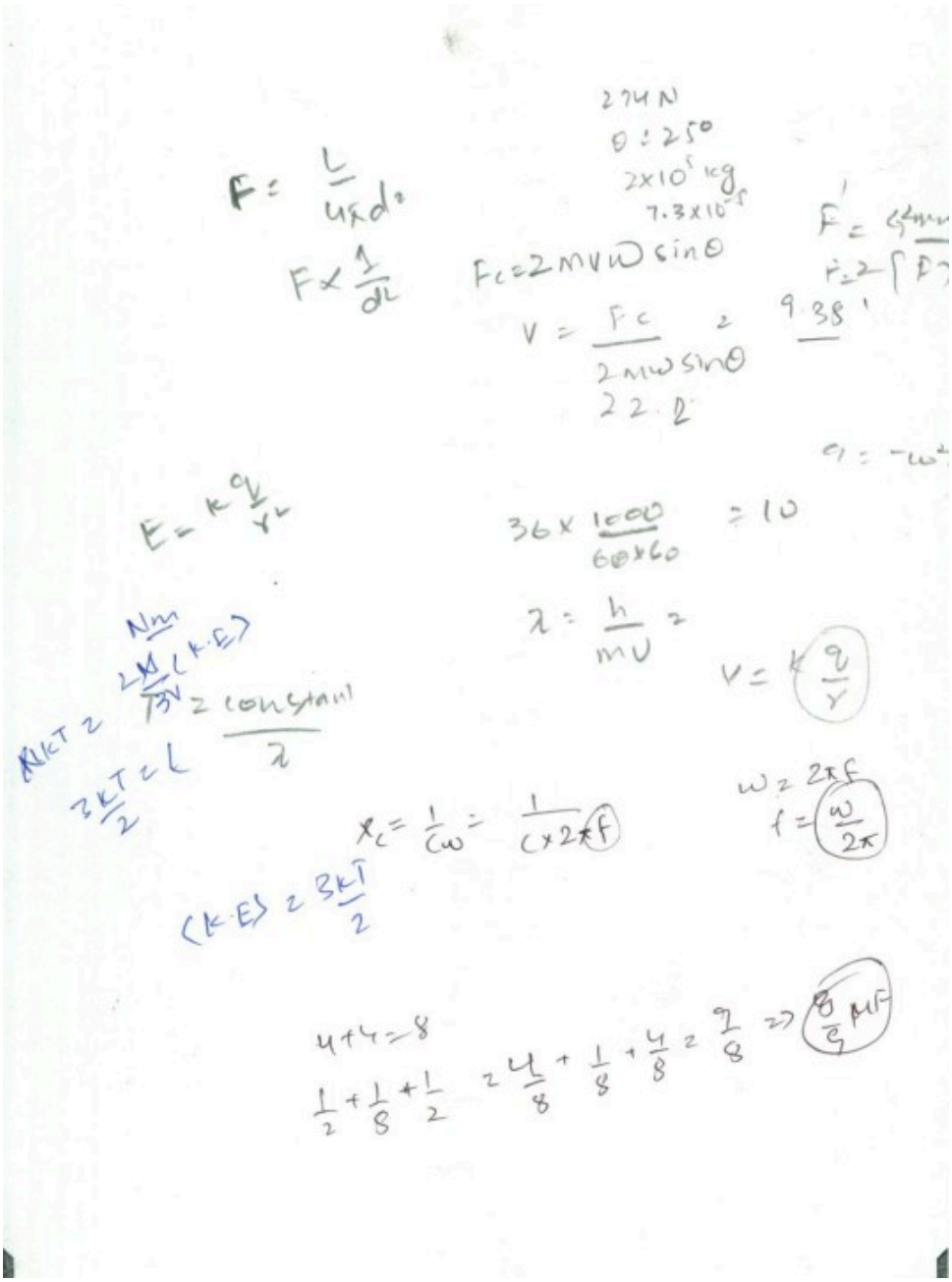






$F = \frac{L}{4\pi d^2}$

$F \propto \frac{1}{d^2}$

274 N

$\theta = 25^\circ$

2×10^5 kg

7.3×10^{-5}

$F_c = 2mv\omega \sin\theta$

$v = \frac{F_c}{2m\omega \sin\theta}$

$E = k\frac{q}{r^2}$

$36 \times \frac{1000}{60 \times 60} = 10$

$\lambda = \frac{h}{mv}$

$V = k\frac{q}{r}$

$\frac{Nm}{\frac{2M}{3V}} \langle K.E \rangle = \text{constant}$

$\frac{\lambda}{KT} = \frac{\text{constant}}{\lambda}$

$\frac{3KT}{2} = L$

$\langle K.E \rangle = \frac{3KT}{2}$

$X_C = \frac{1}{C\omega} = \frac{1}{C \times 2\pi f}$

$\omega = 2\pi f$

$f = \frac{\omega}{2\pi}$

$4 + 4 = 8$

$\frac{1}{2} + \frac{1}{8} + \frac{1}{2} = \frac{4}{8} + \frac{1}{8} + \frac{4}{8} = \frac{9}{8} \Rightarrow \frac{8}{9}\mu F$

(Section B)

Q. No. 2 Part (i) The orbital velocity of satellite will Decrease when it is put into a lower orbit.

Reason:

As $V_o = \sqrt{\frac{GM_e}{r}}$

So $V_o \propto \frac{1}{\sqrt{r}}$

This relation shows that orbital velocity is inversely proportional to square root of distance between earth and satellite.

As satellite is put into lower orbit, 'r' decreases and V_o increases.

Conclusion:

Hence, orbital velocity will increase if satellite is put closer to Earth.

.....

Q. No. 2 Part (ii) **Conditions for Interference Fringes:**

i- Coherent Sources: The light must be from coherent sources, meaning having constant phase relation and to same frequency, wavelength and direction.

ii- Slit Separation: The slit separation must be equal to or comparable to wave length of light.

iii- Monochromatic Light: The light should be monochromatic in order to observe clear fringes.

iv- Stable Environment: The environment must be free from disturbance and should be stable.

(Section B)

Q. No. 2 Part (iii) **Resonance:** It refers to phenomenon in which amplitude of an oscillator reaches its maximum value when driving frequency is equal to natural frequency.

Tuning of Radio Station: Resonance plays a crucial role in tuning of radio station.

When turn the knob of radio and tune it. We are actually changing the natural frequency of electronic circuit. When the natural frequency becomes equal to frequency of transmission radiowaves from radio station. The radiowaves transfer maximum energy and amplitude of radio reaches its maximum value. Due to which, we can hear the radiostation transmission.

Q. No. 2 Part (iv) **Given:** $h = 35700\,km$, $r_e = 6.4\times10^6\,m$

$g = 9.8\,m/s^2$, $m_e = 6\times10^{24}\,kg$

Required: $g_h = ?$

Solution: $h = 35700\times10^3\,m = 3.57\times10^7\,m$

$r = r_e + h = (6.4\times10^6 + 3.57\times10^7\,m) = 4.21\times10^7\,m$

AS $g_h = \dfrac{g r_e^2}{(r_e+h)^2} = \dfrac{g r_e^2}{(r)^2}$

putting values

$g_h = \dfrac{(9.8)(6.4\times10^6)^2}{(4.21\times10^7)^2} = 0.226\,m/s^2$

Hence, 'g' at that height is $0.226\,m/s^2$

(Section B)

Q. No. 2 Part (v)

Given: $C = 0.5\mu F = 5.0 \times 10^{-7} F$

$V = 16 \sin(2 \times 10^3 t)$

Required: $X_C = ?$

Solution: As $V = V_o \sin(\omega t)$

$V = 16 \sin(2 \times 10^3 t)$

$V_o = 16$ and $\omega = 2 \times 10^3$

(i) $f = ?$

As $\omega = 2\pi f$

So $f = \frac{\omega}{2\pi} = \frac{2 \times 10^3}{2(3.14)} = 318.47 Hz$

(ii) $X_C = ?$

As $X_C = \frac{1}{C\omega} = \frac{1}{(5 \times 10^{-7})(2 \times 10^3)}$

$X_C = 1000 \Omega$

(or) $X_C = \frac{1}{C(2\pi f)} = \frac{1}{(5 \times 10^{-7})(2)(3.14)(318.47)}$

$X_C = 999.89 \Omega \approx 1000 \Omega$

Hence, Capacitive reactance is 1000Ω

Q. No. 2 Part (vi)

Atmosphere: It refers to layers of gases that surrounds the Earth.

Role: Atmosphere plays a great role in climate balance.

i- It acts as an insulating layer around the Earth.

ii- It protects us from harmful U.V rays coming from sun which cause alot of skin diseases in humans and other living organisms.

iii- It also prevents extreme changes or variations in climate.

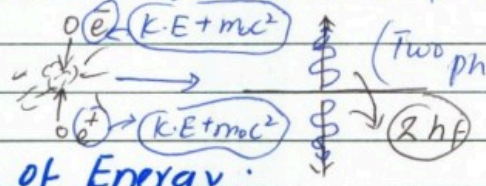
iv- All the weather patterns occur in atmosphere and is responsible for these patterns.

v- Green house gases are present in it which causes to absorb energy reflected by earth surface and influence climate.

(Section B)

Q. No. 2 Part (vii) **Pair Annihilation:**

Definition: The process in which electron and positron combine and annihilate each other to form two photons.



Conservation of Energy:
The energy remain conserved in Pair Annihilation. K.E and mass of electron-positron pair is converted into two photons. $2m_0c^2 + K.E_{e^-} + K.E_{e^+} = 2hf$

Conservation of momentum: Momentum also remain conserved. Momentum of both $\bar{e}$ and e^+ converts into $\frac{h}{\lambda}$ of photon and emitted in opposite direction.

$$mv_{e^-} + mv_{e^+} = 2\frac{h}{\lambda} \text{ (opposite in direction).}$$

Q. No. 2 Part (viii) **Ultrasound:** It refers to sound waves having frequency greater than 20,000 Hz.

Role:

i- Medical imaging: ultrasound plays a very major role in medical imaging. It is widely used in history and now for imaging. It is less harmful than other waves, due to which it is widely used.

ii- Neurosurgery: It is also used in neurosurgery because of its property to be concentrate or focus in a very small area without affecting the nearby tissues or surroundings.

iii - Flow meter: It is also used in flow meters to measure rate or speed fluid flow.

(Section B)

Q. No. 2 Part (ix) Given: $R = 20\,\Omega$, $V_{rms} = 220\,V$, $f = 50\,Hz$

Required: (a) $V_0 = ?$ (b) $I_0 = ?$

Solution:

(a) $V_0 = ?$

As $V_{rms} = \frac{V_0}{\sqrt{2}}$

$\Rightarrow V_0 = V_{rms}\sqrt{2}$

$V_0 = 220 \times \sqrt{2}$

$V_0 = 311.1\,V$

(b) $I_0 = ?$

As $I_0 = \frac{V_0}{R}$

$I_0 = \frac{311.1}{20}$ $\therefore V_0 = 311.1\,V$

$I_0 = 15.5\,A$

Q. No. 2 Part (x) Wein's Displacement Law:

Statement: Black body radiation curve for different temperatures peak at a wavelength, which is inversely proportional to temperature of body.

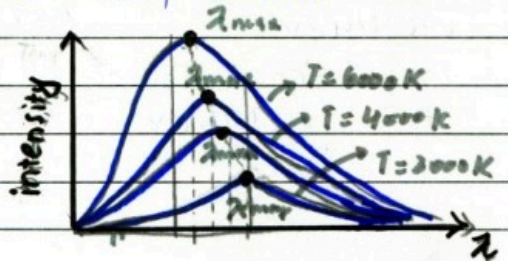
Mathematical expression:

$\lambda_{max} \propto \frac{1}{T}$

$\lambda_{max} = \text{Constant} \frac{1}{T}$

$\because$ Here value of constant is $2.9 \times 10^{-3}\,mK$.

Graph:



(Section B)

Q. No. 2 Part (xi) **Nuclear Reactors:** Devie which is used to initiate and control Nuclear Fission reaction.

i- Control rods:

- It is used to control fission reaction in nuclear reactors by absorbing the **neutrons** released in each Fission reaction.
- It is mostly made of Cadmium (Cd) and Boron (B) which absorbs neutrons.

ii- Moderators: • Water and Graphite are moderators.

- It refers to substances that slow down the neutrons in order to cause another Fission reaction.
- For fission reaction 0.25 eV energy is needed of neutron but as it is released in reaction, it has eV in 10^2 (mega).

.....

Q. No. 2 Part (xii) **Given:** Temperature $= 47°C = 47 + 273 = 320K$

$K = 1.38 \times 10^{-23}$

Required: $\langle K.E \rangle = ?$

Solution: As

$$\langle K.E \rangle = \frac{3KT}{2}$$

$$\Rightarrow \langle K.E \rangle = \frac{3(1.38 \times 10^{-23})(320)}{2}$$

$$\langle K.E \rangle = 6.624 \times 10^{-21} \text{ J} = \frac{6.624 \times 10^{-21}}{1.6 \times 10^{-19}} \text{ eV}$$

$$\langle K.E \rangle = 0.0414 \text{ eV}$$

Hence, average translational K.E will be 6.624×10^{-21} J or 0.0414 eV.

(Section B)

Q. No. 2 Part (xiii) **Peak value of A.C voltage:** It refers to maximum value of voltage in Alternating current.

- It's value is always greater than root mean square value of (AC) voltage.
- It is represented as $V_0 = V_{rms}\sqrt{2}$.

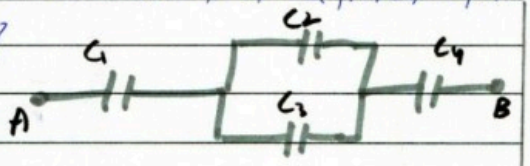
Root mean square value of A.C voltage: It is the effective steady current (D.C) which produces same amount of heat as produced by A.C current or voltage passing through the same resistor for same period of time.

- Its value is always smaller than Peak value of A.C V.
- It is measured as $V = V_0/\sqrt{2}$

Q. No. 2 Part (xiv) **Given:** C_2 and $C_3 = 4\mu F$, $C_1 = 2\mu F$, $C_4 = 2\mu F$

Required: $C_{equivalent} = ?$

Solution:



C_2 and C_3 are in parallel.

So

$C_{eq}' = C_2 + C_3$

$= 4\mu F + 4\mu F = 8\mu F$

Now C_1, C_2 and C_3, and C_4 are in series.

$$\frac{1}{C_{eq(AB)}} = \frac{1}{C_1} + \frac{1}{C_{eq}'} + \frac{1}{C_4}$$

$$\frac{1}{C_{eq(AB)}} = \frac{1}{2\mu} + \frac{1}{8\mu} + \frac{1}{2\mu} = \frac{4+1+4}{8\mu} = \frac{9}{8\mu}$$

reciprocal

$$\Rightarrow C_{eq(AB)} = \frac{8\mu}{9} = \frac{8}{9} \times 10^{-6} F = 0.889 \times 10^{-6} F$$

(Section C)

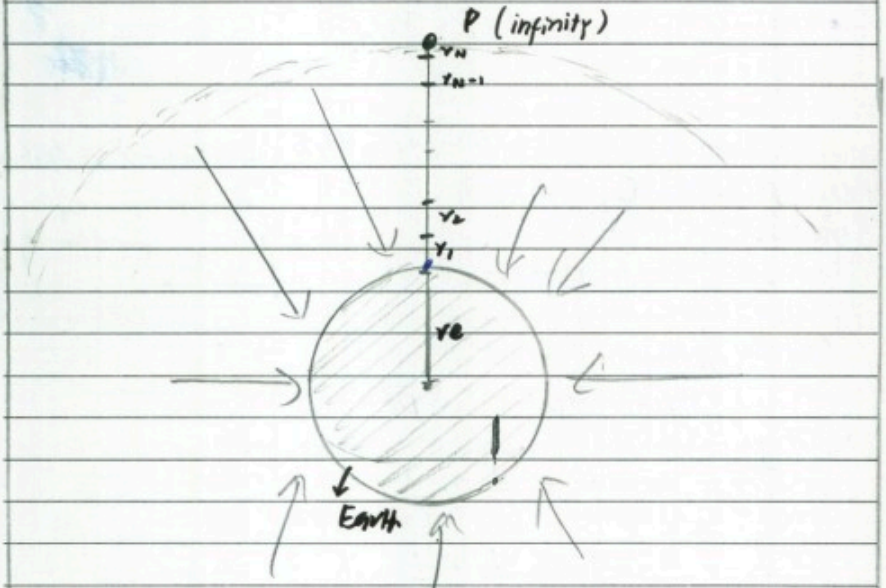
Q. No. 3 (Page 1) **Gravitational Potential:**

Definition: It is the Work done per unit mass in moving a mass from one point to another point while going against the gravitational field.

- It is also defined as Gravitational potential energy per unit mass.
- It is represented as 'V'.

$$V = \frac{\Delta U}{m}$$

Derivation: First, we would like to find value of ΔU = Gravitation potential energy.



let suppose an object of mass m is placed on earth's surface. We applied work done on mass and move it to a point 'P' which is at infinity

(Section C)

Q. No. 3 (Page 2) AG

$P = W = mgh\Delta r$ (But the force will not remain average/or constant due to variation in 'g' value. So we can't use this formula, let, divide the whole distance from centre of earth into fragments. like r_1, r_2 upto r_N.

Now $W_{net} = W_{1\to2} + W_{2\to3} + \cdots W_{n-1\to n}$

$W = F.\Delta r$

$\Rightarrow W = F_{avg}.\Delta r$

$W = F_{avg}\,\Delta r \cos\theta$

$\because \theta = 180^\circ =$

$W = F_{avg}\,\Delta r \cos(180^\circ)$

$W = -F_{avg}\,\Delta r$

$F_{avg} = \frac{G m_e m}{r_{avg}^2}$

$r_{avg} = \frac{r_e + r_1}{2} = \frac{r_e + r_e + \Delta r}{2}$ $\because r_1 = r_e + r_1$

$r_{avg} = \frac{2r_e + \Delta r}{2} = r_e + \frac{\Delta r}{2}$

Taking Square

$r_{avg}^2 = \left(r_e + \frac{\Delta r}{2}\right)^2$

$r_{avg}^2 = r_e^2 + \left(\frac{\Delta r}{2}\right)^2 + 2(r_e)\left(\frac{\Delta r}{2}\right)$

$r_{avg}^2 = r_e^2 + 0 + r_e \Delta r$ $\because \left(\frac{\Delta r}{2}\right)^2 \approx 0$ small value.

$r_{avg}^2 = r_e^2 + r_e(r_1 - r_e) = r_e^2 + r_e r_1 - r_e^2$

(Section C)

Q. No. 3 (Page 3)

Hence,

$r_{avg}^2 = r_e r_1$

Now

$W_{1\to 2} = -\frac{Gmem(\Delta r)}{r_e r_1}$

$W_{1\to 2} = -\frac{Gmem(r_1 - r_e)}{r_e r_1} = -Gmem\left(\frac{r_1 - r_e}{r_e r_1}\right)$

$W_{1\to 2} = -Gmem\left(\frac{1}{r_e} - \frac{1}{r_1}\right)$

find other W, like wise:

$W_{net} = W_1 + W_2 + \cdots + W_{n-1} + W_n$

$= -Gmem\left(\frac{1}{r_e} - \frac{1}{r_1} + \frac{1}{r_1} - \frac{1}{r_2} + \cdots - \frac{1}{r_{N-1}} + \frac{1}{r_{N-1}} - \frac{1}{r_N}\right)$

$= -Gmem\left(\frac{1}{r_e} - \frac{1}{r_N}\right)$

$= -Gmem\left(\frac{1}{r_e} - \frac{1}{\infty}\right) = -Gmem\left(\frac{1}{r_e} - 0\right)$

Hence

$W_{net} = -Gmem\left(\frac{1}{r}\right)$

As $W = P.E = W_{net} = -\frac{Gmem}{r}$

A1(d)

$V = \frac{\Delta U}{m} = \frac{-\frac{Gmem}{r}}{m} = -\frac{Gme}{r_e}$

Hence,

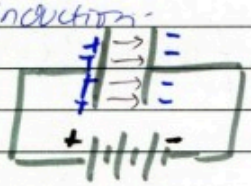
Gravitational Potential $= -\frac{Gme}{r_e} = \left[-\frac{Gm}{r}\right]$

(Section C)

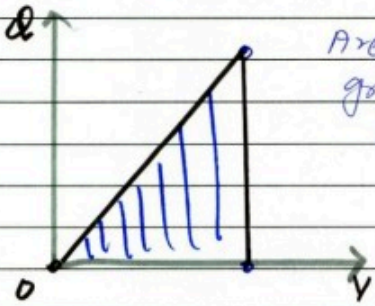
Q. No. 4 (Page 1)

Energy stored in ~~Potentic~~ Capacitors

- Capacitor store electrical energy in form of electric field.
- When Capacitor is connected to a battery, electric charges accumulate on one plate and moves away from other plate. As a result, electrical field is established which stores electrical energy due to electrostatic induction.



Graph:



Area under Q vs V graph gives the energy stored in capacitor.

Area of triangle = energy stored = E

$\Rightarrow E = \frac{1}{2}$ (length x breadth)

(i) $E = \frac{1}{2} QV$

(Section C)

Q. No. 4 (Page 2)

Also

$$E = \frac{1}{2} QV = \frac{1}{2}(CV)V$$

(ii) $E = \frac{1}{2}CV^2$

Or

$$E = \frac{1}{2}\left(\left(\frac{Q}{C}\right)^2\right) = \frac{1}{2}\frac{Q^2}{C^2}(C)$$

(iii) $E = \frac{Q^2}{2C}$

Hence

$$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{Q^2}{2C}$$

(b)

Given: $Q = 5C$

$V = 15\ V.$

Required:

$E = ?$

Solution:

As

$$E = \frac{1}{2}QV$$

$$E = \frac{1}{2}(5C)(15)$$

$$E = 37.5\ \text{Joules}$$

(Section C)

Q. No. 4 (Page 3)

(Section C)

Q. No. 5 (Page 1)

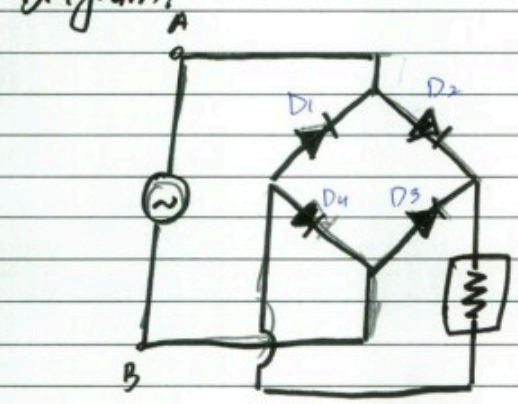
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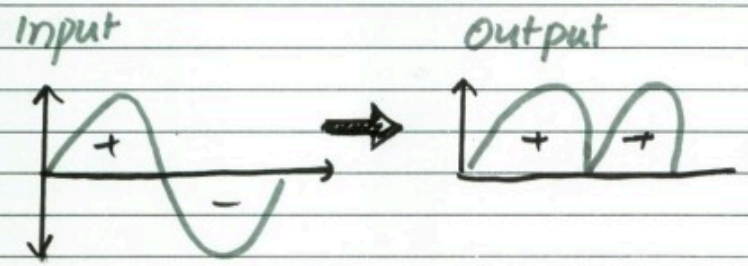
Process of converting A.C voltage into DC voltage with the help of diode is called rectifier.

Bridge Rectifier:

- It is a full wave rectifier.
- It has 4 diodes
- It completely converts input A.C into pulsating D.C.

Diagram:

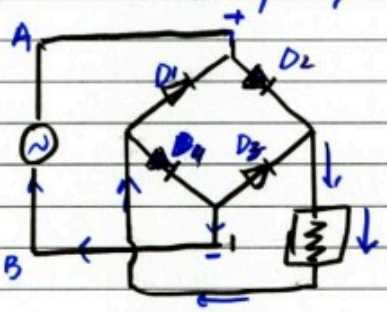




(Section C)

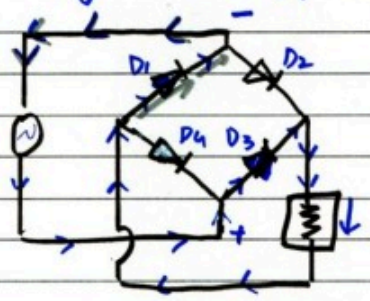
Q. No. 5 (Page 2)

i) Positive half Cycle:



- In positive half cycle, point A gets (+ive) charge, while point B gets (-ive charge)
- So charges flows from point A to B as the diode **D2** and **D4** become **forward biased** while D3 and D1 are reverse biased.
- Charges flow in downward direction from load due to small resistance from forward biased diodes and get to negative terminal.
- **D2 and D4** will conduct charges and will act as a closed circuit.

ii) Negative Half Cycle:



(Section C)

Q. No. 5 (Page 3) In negative half cycles point 'A' will get negative charge while point 'B' will get (+ive) charge.

- charges will flow from point 'B' through diode D_3 and then to load. It will move towards negative charged 'A' point through diode D_1.
- In negative half cycles D_1 and D_3 will be forward biased. Hence, they will act as a closed circuit and will allow charges to pass through it.
- D_1 and D_3 will forward biased and the charges will move throug load in the same direction.

(Section C)

Q. No. 6 (Page 1)

(a)

Luminosity:

Definition: It is the total power output of electromagnetic radiations from a black body.

representation: It is presented as 'L'
Its unit is 'J/s' or watt.

Stefan Boltzmann Law:
It gives relationship between luminosity, radius and temperature.

Statement: It states that the energy of radiations from a body per unit area per second is directly proportional to fourth power of Temperature of body.

Mathematically:

$$\frac{L}{A} \propto T^4$$

$$\frac{L}{A} = 6T^4 \quad \because \text{'6' Stefan-boltzmann's Constant and is equal to } 5.67 \times 10^{-8}$$

$$\Rightarrow L = A6T^4$$

$$\Rightarrow L = 4\pi r^2 T^4$$

(Section C)

Q. No. 6 (Page 2)

(b)

Given: $T_A = 100K$, $T_B = 200K$

$R_A = 10m$, $R_B = 5m$

Required: (a) $L_A = ?$

(b) $L_B = ?$

Solution:

(a) As

$L = 4\pi r^2 \sigma T^4$

So

$L = 4(3.14)(10)^2(5.67\times10^{-8})(100)^4$

$= (1256)(5.67\times10^{-8})(10^8)$

$= 1256\,(5.67)$

$= 7121.52$ watt.

(b) As

$L = 4\pi r^2 \sigma T^4$

$= 4(3.14)(5)^2(5.67\times10^{-8})(200)^4$

$= 314\,(5.67\times10^{-8})(1.6\times10^9)$

$= 1.78\times10^{-5}\,(1.6\times10^9)$

$= 28486.08$ J

(c)

$\frac{L_A}{L_B} = \frac{7121.52}{28486.08} = 0.25 = \frac{1}{4}$

$\Rightarrow L_B = 4L_A$

(Section C)

Q. No. 6 (Page 3) OR

$$\frac{L_A}{L_B} = \frac{4\pi (10^2)^4 (100)^4}{4\pi (5^2)^4 (200)^4}$$

$$\frac{L_A}{L_B} = \frac{100 \times 10^8}{25 \times 1.6 \times 10^9}$$

$$\frac{L_A}{L_B} = \frac{4 \times 10^8}{1.6 \times 10^9} = \frac{1}{4}$$

$$\Rightarrow L_B = 4L_A$$