Solution

PHYSICS

Class 12 - Physics

Section A

1. Select and write the correct answers for the following multiple choice type of questions:

(i) **(d)** $\frac{hv}{c}$
Explanation: {
The momentum associated with photon is given by $\frac{hv}{c}$.

(ii) **(c)** $W = Q$
Explanation: {
For a cyclic process, the total change in the internal energy of a system is zero.
$\therefore \Delta U = 0$
According to the first law of thermodynamics,
$Q = \Delta U + W$
$\therefore Q = W$

(iii) **(c)** OR
Explanation: {
OR

(iv) **(c)** $\frac{a}{1.22\lambda}$
Explanation: {
$\frac{a}{1.22\lambda}$

(v) **(b)** λ
Explanation: {
λ

(vi) **(d)** surface tension
Explanation: {
surface tension

(vii) **(b)** 4
Explanation: {
$\frac{r_8}{r_4} = \left(\frac{8}{4}\right)^2 = 2^2 = 4 \Rightarrow r_8 = 4r_4$

(viii) **(a)** shows a depression in the middle.
Explanation: {
shows a depression in the middle.

(ix) **(a)** watt$/m^2$
Explanation: {
watt$/m^2$

(x) **(b)** NOR gate
Explanation: {
NOR gate

2. Answer the following questions:

(i) No. Any light possessing sufficient energy to initiate the photoemission can be used to get photoelectric effect.

(ii) **Differential equation for angular S.H.M.:**
$I\frac{d^2\theta}{dt^2} + c\theta = 0$

(iii) In parallel resonant circuit, current is minimum and impedance is maximum.

(iv) For an ideal voltmeter the value of resistance is infinite.

(v) Value of tangential acceleration in U.C.M. is always zero.

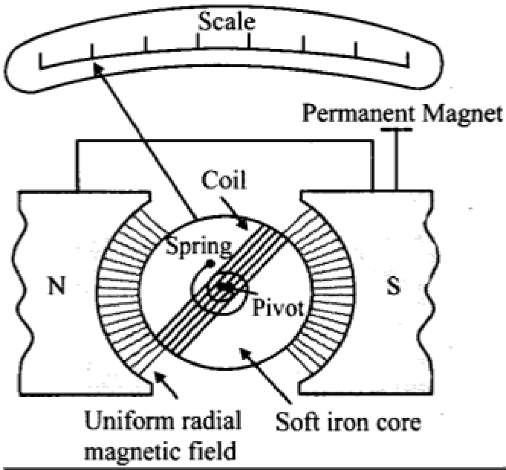
(vi) Expression for electric field intensity at a point outside an infinitely long charged conducing cylinder:
$E = \frac{\lambda}{2\pi k \varepsilon_0 r}$

(vii) Force on a closed circuit in a magnetic field is zero.

(viii) The ratio of magnetic moment to the volume of the material is called magnetization.

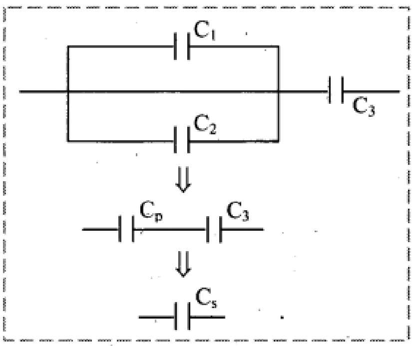
Section B

3. **Capillary action or capillarity:**
The phenomenon of rise or fall of liquid level inside a capillary tube when it is dipped in the liquid is called capillary action or capillarity.
Uses of capillarity:
   i. Oil rises up the wick of a lamp.
   ii. Cloth rag sucks water.
   iii. Water rises up the crevices in rocks.
   iv. Sap and water rise up to the top most leaves in a tree.
   v. Blotting paper absorbs ink.

4. 

5.

Centripetal force	Centrifugal force
Centripetal force is directed along the radius towards the centre of a circle.	Centrifugal force is directed along the radius away from the centre of a circle.
It is a real force.	It is a pseudo force.
It is considered in inertial frame of reference.	It is considered in non-inertial frame of reference.
In vector form, it is given by $\vec{F} = -\frac{mv^2}{r}\hat{r}_0$ with usual notations.	In vector form, it is given by $\vec{F} = +\frac{mv^2}{r}\hat{r}_0$ with usual notations.

6. i. 

   ii. When the capacitors C_1 and C_2 are connected in parallel, the effective capacitance C_P is
   $C_P = C_1 + C_2$
   Now, when C_P is connected in series with C_3, we get the effective capacitance C_S as
   $\frac{1}{C_s} = \frac{1}{C_P} + \frac{1}{C_3}$
   $= \frac{C_3 + C_P}{C_p C_3}$
   $\therefore C_S = \frac{C_p C_3}{C_3 + C_p} = \frac{(C_1 + C_2)C_3}{C_3 + C_1 + C_2} = \frac{C_1 C_3 + C_2 C_3}{C_1 + C_2 + C_3}$

7. **Definition:** The physical quantity which describes the state of oscillation of a particle performing S.H.M at the start of motion is called epoch of S.H.M.

   Factors affecting total energy: Total energy of particle performing S.H.M. depends on the mass, amplitude and frequency of motion of the particle.

8. **Thermodynamic process:** A process by which two or more of state variables of a system can be changed is called a thermodynamic process or a thermodynamic change.

   Types of thermodynamic processes:

   i. Quasi-static process
   ii. isothermal process
   iii. adiabatic process
   iv. isochoric process
   v. isobaric process
   vi. reversible process
   vii. irreversible process
   viii. cyclic process

   (Any two types)

9. Given: $L = 0.1H, C = 25 \times 10^{-6}\ F, R = 15\Omega$

   $e_{rms} = 120\ V$

   To find: Resonant frequency (f_r)

   Formula: $f_r = \frac{1}{2\pi\sqrt{LC}}$

   Calculation: From formula,

   $f_r = \frac{1}{2\times3.142\times\sqrt{0.1\times25\times10^{-6}}}$

   $= \frac{1}{9.9356\times10^{-3}}$

   $f_r = 100.6\ Hz$

   The value of resonant frequency is $100.6Hz$.

10. Given: x = $\frac{A}{3}$

    To find: Ratio of kinetic and total energy $\left(\frac{\text{K.E.}}{\text{T.E.}}\right)$

    Formulae:

    1. T.E. $= \frac{1}{2}kA^2$
    2. K.E. $= \frac{1}{2}k\left(A^2 - x^2\right)$

    Calculation: From formula (ii)

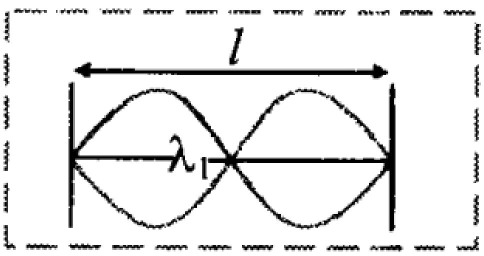
    K.E. $= \frac{1}{2}k\left[A^2 - \left(\frac{A}{3}\right)^2\right] = \frac{1}{2}k\left[A^2 - \frac{A^2}{9}\right] = \frac{1}{2}k \times \frac{8\,A^2}{9}$

    From formulae (i) and (ii),

    $\frac{\text{K.E.}}{\text{T.E.}} = \frac{\frac{1}{2}kA^2\left(\frac{8}{9}\right)}{\frac{1}{2}kA^2} = \frac{8}{9}$

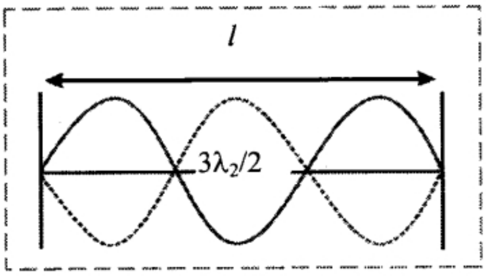
    The ratio of kinetic and total energy is **8 : 9**.

11. i. **For second harmonic:**



Second mode

ii. **For third harmonic:**



12. Given: $T = 727 + 273 = 1000\ K$

$\sigma = 5.7 \times 10^{-8}\ J/m^2 sK^4, e = 0.2$

To find: Power radiated (P)

Formula: $P = \frac{Q}{At} = \sigma e T^4$

Calculation: From formula,

$P = 5.7 \times 10^{-8} \times 0.2 \times (1000)^4 = 11400$

$\therefore P = 1.14 \times 10^4 watt/m^2$

The power radiated per unit area is $1.14 \times 10^4 watt/m^2$.

13. Given: $l_1 = 3.2\ m, l_2 = 0.7\ m$

To find: Ratio of emfs of two cells $\left(\frac{E_1}{E_2}\right)$

Formula: $\frac{E_1}{E_2} = \frac{l_1 + l_2}{l_1 - l_2}$

Calculation: From formula,

$\frac{E_1}{E_2} = \frac{3.2+0.7}{3.2-0.7} = \frac{3.9}{2.5} = 1.56$

The ratio of emfs of two cells is 1.56.

14. Given: $h = 6.63 \times 10^{-34}\ J.s,\ E_1 = -13.6eV, E_n = -0.85eV$

To find: Angular momentum of the electron (L)

Formulae: i. $E_n = \frac{E_1}{n^2}$

ii. $L = \frac{nh}{2\pi}$

Calculation: Using formula (i)

$-0.85 = \frac{-13.6}{n^2} = 16$

$n^2 = \frac{-13.6}{-0.85}$

$\therefore n = 4$

Using formula (ii)

$L = \frac{4 \times 6.63 \times 10^{-34}}{2 \times 3.142} = \frac{2 \times 6.63}{3.142} \times 10^{-34}$

$= \{\text{antilog}[\log(2) + \log(6.63) - \log(3.142)]\} \times 10^{-34}$

$= \{\text{antilog}[0.3010 + 0.8215 - 0.4972]\} \times 10^{-34}$

$= \{\text{antilog}[0.6253]\} \times 10^{-34}$

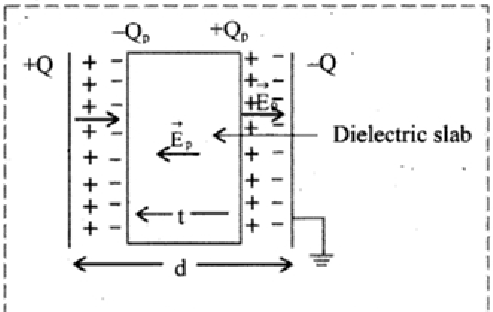
$\therefore\ L = 4.22 \times 10^{-34} kg\ m^2/s$

The angular momentum of the electron in the fourth orbit in a hydrogen atom is $4.22 \times 10^{-34}\ kg\ m^2/s$.

Section C

15. Conditions for obtaining sharp and steady interference pattern are:

i. The two sources of light must be coherent.
ii. The two sources of light must be monochromatic.
iii. The two interfering waves must have the same amplitude.
iv. The separation between the two slits (d) must be small in comparison to the distance between the plane containing the slits and the observing screen (D).
v. The two slits should be narrow.
vi. The two waves should be in the same state of polarization if polarized light is used for the experiment.

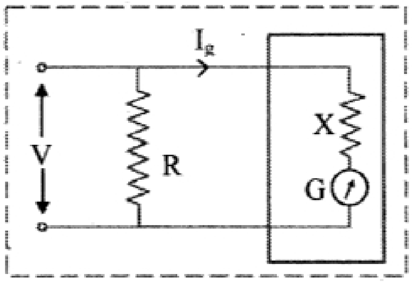
16. 

Parallel plate capacitor with a dielectric slab between the

17. i. **Magnetization:** The ratio of magnetic moment to the volume of the material is called magnetization.
It is denoted by $\vec{M}$.
Unit: Am^{-1} in SI system.
ii. **Magnetic susceptibility:** The ratio of magnitude of intensity of magnetization to that of magnetic intensity is called as magnetic susceptibility.
Magnetic susceptibility is unitless and dim ensionless quantity.

18. **Construction of photoelectric cell:**
i. A photo cell consists of a semi-cylindrical photosensitive metal plate E acting as a cathode and a wire loop collector C acting as an anode supported in an evacuated glass or quartz bulb.
ii. The electrodes are connected to an external circuit having a high tension battery B and a micro ammeter μA.
iii. Instead of a photosensitive metal plate, the photosensitive material can be pasted in the form of a thin film on the inner walls of the glass bulb.

19. i. To use a M.C.G as a voltmeter, a high resistance is connected in series with the M.C.G.
ii. A very high resistance X is connected in series with the galvanometer for this purpose as shown in figure.



iii. If V is the voltage to be measured, then
$V=I_gX+I_gG$
$\therefore I_gX=V-I_gG$
$\therefore X=\frac{V}{I_g}-G$ ...(1)
where I_g is the current flowing through the galvanometer.
iv. If voltage V is n_v times voltage V_g (voltage across galvanometer) then,
$V=n_vV_g=n_v\left(I_gG\right)$
Using this in equation (1),
$X=G\left(n_v-1\right)$.

20. i. When a source of sound and the listener are in relative motion, the listener detects a sound whose frequency is different from the actual or original frequency of the sound source. This is Doppler effect.
ii. **Application of Doppler effect:**
a. The principle of Doppler effect is used by traffic police to determine the speed of a vehicle to check whether speed limit is exceeded.
b. SONAR works on the principle of Doppler effect for determining the speed of submarines using a sound source and sensitive microphones.
c. Doppler ultrasonography and echo cardiogram work on Doppler effect.
d. Speed of an airplane can be determined using doppler RADAR.

21. i. For parallel combination of two coils, the current through each parallel inductor is a fraction of the total current and the voltage across each parallel inductor is same.

ii. As a result, a change in total current will result in less voltage dropped across the parallel array than for any one of the individual inductors.
iii. There will be less voltage drop across parallel inductors for a given rate of change in current than for any of the individual inductors.
iv. Less voltage for the same rate of change in current results in less inductance.
v. Thus, the total inductance of two coils is less than the inductance of either coil.

22. Given: $n_1 = 256\ Hz, \Delta l = 10\ cm = 0.1\ m$
$n_2 = 320\ Hz$
To find: Length (l)
Formula: $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$
Calculation: From first condition,
$256 = \frac{1}{2l}\sqrt{\frac{T}{m}}$ ...(1)
From second condition,
$320 = \frac{1}{2(l-0.1)}\sqrt{\frac{T}{m}}$ ...(2)
Dividing equation (1) by (2)
$\frac{256}{320} = \frac{2(l-0.1)}{2l}$
$\frac{4}{5} = \frac{l-0.1}{l} = 1 - \frac{0.1}{l}$
$\therefore \frac{0.1}{l} = 1 - \frac{4}{5} = \frac{1}{5}$
The original length of wire is $50\ cm$.

23. Given: $i = 60^\circ, n_g = 1.5$
Let $d_g =$ width of beam in glass slab,
$d_a =$ width of beam in air
To find the ratio of widths $\left(\frac{d_g}{d_a}\right)$
Formulae:
i. $n_g = \frac{\sin i}{\sin r}$
ii. $\frac{dg}{d_a} = \frac{\cos r}{\cos i}$
Calculation: From formula (i),
$\sin r = \frac{\sin i}{n_8}$
$\therefore \sin r = \frac{\sin 60^\circ}{1.5} = \frac{0.8660}{1.5} = 0.5773$
$\therefore r = \sin^{-1}(0.5773) = 35^\circ 16'$
From formula (ii),
$\frac{d_g}{d_a} = \frac{\cos r}{\cos i} = \frac{\cos 35^\circ 16'}{\cos 60^\circ}$
$\therefore \frac{d_g}{d_g} = \frac{0.8164}{0.5} = 1.6$
$\therefore \frac{d_g}{d_a} = \frac{16}{10} = 8 : 5$
$\therefore$ Ratio of the widths of beam $= 8 : 5$
The ratio of widths of the beam in glass to that in air is $8 : 5$.

24. Given: $N = 250,\ d = 18\ cm,\ r = 9\ cm = 9 \times 10^{-2}\ m, I = 12\ A$
To find: Magnetic moment of the coil (m)
Formula: m = NIA
Calculation: For the coil,
$A = \pi r^2$
Using formula,
$m = NI\pi r^2$
$= 250 \times 12 \times 3.142 \times \left(9 \times 10^{-2}\right)^2$
$= 250 \times 12 \times 3.142 \times 81 \times 10^{-4}$
$= \{\text{antilog}[\log(250) + \log(12) + \log(3.142) + \log(81)]\} \times 10^{-4}$
$= \{\text{ antilog } [2.3979 + 1.0792 + 0.4972 + 1.9085]\} \times 10^{-4}$
$= \{\text{ antilog}[5.8828]\ \} \times 10^{-4}$

$= 0.7635 \times 10^6 \times 10^{-4}$

$\therefore$ m = **76.35 Am²**

Magnetic moment of the coil is **76.35 Am²**.

25. Given: $e = 140 \sin 314.2t$

    i. On comparing it with standard equation,

    $e = e_0 \sin \omega t$

    We get

    $e_0 = 140\ V$

    $\omega = 314.2 rad/s = 100\pi rad/s$

    $\therefore f = \frac{\omega}{2\pi} = \frac{100\pi}{2\pi} = 50\ Hz$

    ii. Given: $R = 50\Omega$

    $i_{rms} = \frac{e_{ms}}{R} = \frac{e_0}{\sqrt{2} \times R}$

    $= \frac{140}{\sqrt{2} \times 50}$

    $= \frac{14}{1.414 \times 5}$

    $= \frac{14}{7.07} \approx 1.98\ A$

    i. The frequency of the source is 50 Hz.

    ii. The rms current through the resistor is 1.98 A.

26. Given: For longest wavelength $m = 2$, for shortest wavelength $m = \infty$

    To find: i. Longest wavelength (λ_L)

    ii. Shortest wavelength (λ_s)

    Formula: $\frac{1}{\lambda} = R_H \left[\frac{1}{1^2} - \frac{1}{m^2}\right]$

    Calculation: The ultraviolet region for hydrogen atom lies in the Lyman series.

    For the longest wavelength (λ_L), from formula,

    $\frac{1}{\lambda_L} = R_H \left[\frac{1}{1^2} - \frac{1}{2^2}\right]$

    $\frac{1}{\lambda_L} = \frac{3R_H}{4}$

    $\therefore \lambda_L = \frac{4}{3R_H}$ ... (1)

    For Lyman series shortest wavelength (λ_S), from formula,

    $\frac{1}{\lambda_s} = R_H \left[\frac{1}{1^2} - \frac{1}{\infty^2}\right]$

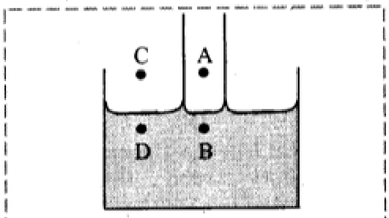
    $\therefore \frac{1}{\lambda_S} = R_H$

    $\therefore \lambda_S = \frac{1}{R_H}$ ...(2)

    The expression for longest and shortest wavelength of spectral lines in ultraviolet region for hydrogen atom is $\frac{4}{3R_H}$ and $\frac{1}{R_H}$ respectively.

Section D

27. Explanation of capillary action:

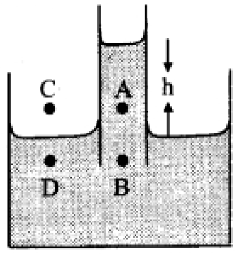


Capillary just immersed in water

i. Suppose a capillary tube is dipped into water.

ii. Consider the situation before the movement of water inside the capillary. The shape of the surface of water in the capillary is concave.

iii. Let us consider four points as shown in the figure. Point A is just above the concave surface inside the capillary. B is just below the concave surface inside the capillary. C is just above the plane surface outside the capillary. D is just below the plane surface outside the capillary and is at the same horizontal level as that of B.



'Capillary in water after rise in level

iv. Let P_A, P_B, P_C and P_D be the pressures at points A, B, C and D respectively.

v. Since pressure on concave side of liquid surface is greater than that on the convex side.

$\therefore P_A > P_B$

vi. As the pressure is same on both sides of a plane surface,

$\therefore P_C = P_D$

vii. The points A and C are at the same level, the pressure at both these points is the same.

$P_A = P_C = P_D =$ atmospheric pressure

$\therefore P_D > P_B$

viii. But points B and D are at same horizontal level in the liquid. Therefore, in order to maintain the same pressure, the liquid out of the capillary flows into the capillary tube and rises above the point B, till the pressure at B becomes the same as that at D. Because of this, there is a rise in the level of liquid inside the capillary tube.

28. Answer the following questions:

(i)

Step-up transformer	**Step-down transformer**
(1) The number of turns in its secondary is more than that in its primary $(\mathrm{N_S} > \mathrm{N_P})$.	The number of turns in primary is greater than secondary $(\mathrm{N_P} > \mathrm{N_S})$.
(2) Alternating voltage across the ends of its secondary is more than that across its primary i.e., $e_S > e_P$	Alternating voltage across the ends of the primary is more than that across its secondary i.e., $e_P > e_S$
(3) Transformer ratio K > 1.	Transformer ratio K < 1.
(4) Primary coil made of thick wire.	Secondary coil made of thick wire.
(5) Secondary coil is made of thin wire.	Primary coil is made of thin wire.
(6) Current through secondary is less than primary.	Current through primary is less than secondary.

(ii) Given: $e = 91mV = 91 \times 10^{-3}\ V,\ \frac{dI}{dt} = 1.3\ A/s$

To find: Mutual Inductance (M)

Formula: $M = \frac{|e|}{|\frac{dI}{dt}|}$

Calculation: From formula

$M = \frac{91 \times 10^{-3}}{1.3} = 70 \times 10^{-3} = 70mH$

Mutual Inductance of the two coils is **70 mH.**

29. Answer the following questions:

(i) i. Mechanical equilibrium:

a. For a system to be in mechanical equilibrium, there should not be any unbalanced forces acting within the system and between the system and its surrounding.

b. Also, the pressure in the system should be same throughout the system and should not change with time.

ii. **Thermal equilibrium:**

For a system to be in thermal equilibrium, the temperature of the system should be uniform throughout and it should not change with time. A system when in thermal equilibrium is described in terms of state variables.

(ii) Given: $W = -104\ J, Q = -125\ kJ = -125000\ J$

To find: Change in internal energy $(\Delta\mathrm{U})$

Formula: $\Delta\mathrm{U} = |\mathrm{Q}| - |\mathrm{W}|$

Calculation: From formula,

$\Delta U = |Q| - |W|$

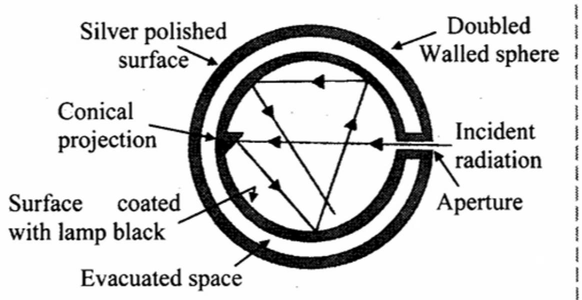
$\therefore \Delta U = (125000 - 104)J = 124896\ J$

= 124.896 kJ

Change in internal energy is 124.896 kJ.

30. Answer:

(i) **Definition:** A body, which absorbs the entire radiant energy incident on it, is called an ideal or perfect blackbody.



Ferry's blackbody

(ii) Given: $A = 200\ cm^2 = 200 \times 10^{-4} m^2$,

$T = 127^\circ C = (127 + 273)K = 400\ K$

$t = 0.5\ min = 30\ s$;

Also, $\sigma = 5.7 \times 10^{-8} Jm^{-2}s^{-1}K^{-4}$

To find: Energy radiated (Q)

Formula: $Q = \sigma A t T^4$

Calculation: From formula,

$Q = \sigma A t T^4$

$= 5.7 \times 10^{-8} \times 200 \times 10^{-4} \times 30 \times (400)^4$

$= 5.7 \times 10^{-8} \times 0.6 \times 10^4 \times 10^{-4} \times 4^4 \times 10^8$

$= 5.7 \times 0.6 \times 256 = 875.5\ J$

Energy radiated in one minute is $875.5\ J$.

31. **Statement:** Angular momentum of an isolated system is conserved in the absence of an external unbalanced torque.

Proof:

i. Angular momentum or the moment of linear momentum of a system is given by,

$\vec{L} = \vec{r} \times \vec{p}$

where $\vec{r}$ is the position vector from the axis of rotation and $\vec{p}$ is the linear momentum.

ii. Differentiating with respect to time, we get,

$\frac{d\vec{L}}{dt} = \frac{d}{dt}(\vec{r} \times \vec{p}) = \vec{r} \times \frac{d\vec{p}}{dt} + \frac{d\vec{r}}{dt} \times \vec{p}$

iii. Now, $\frac{d\vec{r}}{dt} = \vec{v}$ and $\frac{d\vec{p}}{dt} = \vec{F}$

$\therefore \frac{d\vec{L}}{dt} = \vec{r} \times \vec{F} + m(\vec{v} \times \vec{v})$

Now $(\vec{v} \times \vec{v}) = 0$

$\therefore \frac{d\vec{L}}{dt} = \vec{r} \times \vec{F}$

iv. But $\vec{r} \times \vec{F}$ is the moment of force or torque $\vec{\tau}$.

$\therefore \vec{\tau} = \frac{d\vec{L}}{dt}$

Thus, if $\vec{\tau} = 0$, $\frac{d\vec{L}}{dt} = 0$ or $\vec{L} =$ constant.

Hence, angular momentum $\vec{L}$ is conserved in the absence of external unbalanced torque $\vec{\tau}$.