నమస్తే తెలంగాణ
నిపుణ II
Guide to Excellence
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పోటీపరీక్షల ప్రత్యేకం
ఆదివారం 29 అక్టోబర్ 2023

ఆస్టిగ్మాటిజం దేని కారణంగా వస్తుంది?
కార్నియా నిర్మాణ లోపం వల్ల

రైనాలజీ అనేది దేనికి సంబంధించినది?
ముక్కు అధ్యయనం

నాలుక గురించి అధ్యయనం చేయడాన్ని ఏమంటారు?
లారింజాలజీ

నాలుకలోని ముందు భాగం ఏ రుచిని తెలియజేస్తుంది?
తీపి, ఉప్పు

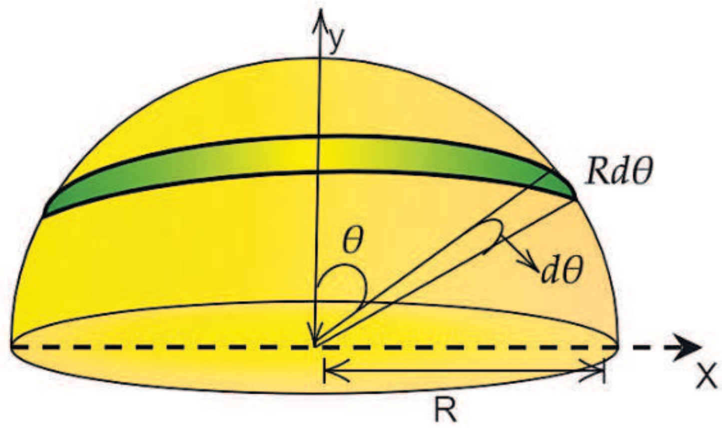
The motion of the centre of mass depends on..

Centre of Mass

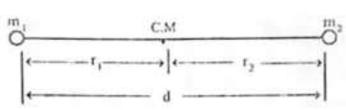
- **Centre of Mass:** The Centre of mass of a body is the point within the boundaries of the body where the total mass of the body appears to be conce -ntrated and when external force acts on the point, the body undergoes translatory motion.
- The motion of Centre of mass of a body represents the motion of the whole body.
- The position of Centre of mass is independent of co-ord -inate system and its position remains constant relative to any particles of the system.
- The position of the Centre of mass of a body depends upon the shape of the body, masses of the particles of the body and relative separation between them.
- For symmetrical bodies with homogeneous mass distri - bution, the Centre of mass coincides with the Centre of symmetry or geometrical Centre.
- The Centre of mass of a body need not be where there is mass. It may lie within the body or outside.

Ex: The Centre of mass of a circular disc is at the Centre of the disc (within the body). But the Centre of mass of a circular ring is at its Centre (outside the body).

- For a rigid system, the pos- ition of Centre of mass does not vary with time. For a non rigid system, the position of Centre of mass varies with time (**Ex :** solar system).
- When a body is in translatory motion, the Centre of mass of the body also have translatory motion.
- When a body is in rotatory motion only, the Centre of mass of the body is at rest.
- When a body is rolling on a surface (i.e., having transl - atory and rotatory motion simultaneously)then its Centre of mass has trans - latory motion only.
- **Centre of Gravity:** The Centre of gravity of a body is the point where its total weight can be supposed to act.
- **Centre of gravity is related to weight of all particles of the body. Note:** If the body is small, the Centre of mass and the Centre of gravity coincide. But if the body is huge (like a mountain) where 'g' is not uniformly distri - buted, the Centre of mass and the Centre of gravity differ.



- In case of symmetrical bodies the Centre of mass coincide with the geometrical Centre.
- If two particles of masses m_1, m_2 are separated by distance 'd' and r_1, r_2 are the distance of their centre of mass from m_1 and m_2 then $m_1r_1 = m_2r_2$



- i.e., The distance of the particles from centre of mass are in the inverse ratio of their masses.

$$\Rightarrow \frac{r_1}{r_2} = \frac{m_2}{m_1}$$

i) Distance of the centre of mass 'm_1' is given by

$$r_1 = \left(\frac{d}{m_1+m_2}\right) m_2$$

ii) Distance of the centre of mass from 'm_2' is given by

$$r_2 = \left(\frac{d}{m_1+m_2}\right) m_1$$

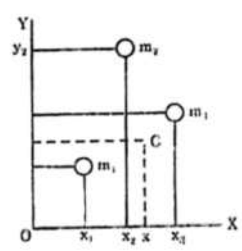
- The moments of forces or masses of the system about Centre of mass is equal to zero.
- If x1, x2 are the distance of the particles from the origin and XCM is the distance of the centre of mass of the system of the origin,

then $X_{CM} = \frac{m_1x_1+m_2x_2}{m_1+m_2}$

For n particle system

$$X_{CM} = \frac{\Sigma m_1 x_1}{M}$$

- The motion of the Centre of the mass depends on the mass depends on the external forces acting on the system.
- The motion of the centre of mass does not depend on the internal forces acting on the system.
- Centre of mass for a System of Particles: Let a system of particles of masses m1, m2, m_3.......lie in the X-Y plane with respective co-ordinate (x1, y1) , (x2, y2) , (x3, y3). And x and y are the co-ordinates of their centre of mass C.



$$X_{CM} = \frac{m_1x_1+m_2x_2+m_3x_3}{m_1+m_2+m_3} \quad ....(1)$$

And

$$Y_{CM} = \frac{m_1y_1+m_2y_2+m_3y_3}{m_1+m_2+m_3} \quad ....(2)$$

- Let a system of particles of masses m1, m2, m3 …. Lie in space with co-ordinates (x1, y1,z1) ,(x2, y2, z2) , (x3, y3, z3) … then the co-ordinates of C.M. of the system are

And

$$Y_{CM} = \frac{m_1y_1+m_2y_2+m_3y_3}{m_1+m_2+m_3} \quad ....(2)$$

Let a system of particles of masses m_1, m_2, m_3 .... Lie in space with co-ordinates (x_1, y_1,z_1) ,(x_2, y_2, z_2) , (x_3, y_3, z_3) ... then the co-ordinates of C.M. of the system are

$$X_{CM} = \frac{m_1x_1+m_2x_2+m_3x_3+\cdots}{m_1+m_2+m_3+\cdots}$$

$$Y_{CM} = \frac{m_1y_1+m_2y_2+m_3y_3+\cdots}{m_1+m_2+m_3+\cdots}$$

$$Z_{CM} = \frac{m_1z_1+m_2z_2+m_3z_3+\cdots}{m_1+m_2+m_3+\cdots}$$

If r is the distance of the centre of mass from the origin of the coordinate system, then

$$r = \sqrt{X_{CM}^2 + Y_{CM}^2 + Z_{CM}^2}$$

if $\vec{r_1}$ and $\vec{r_2}$ are the position vectors of the particles having masses m1 and m2 then the

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position vectors of the centre of mass of the system is

$$\vec{r_{CM}} = \frac{m_1\vec{r_1} + m_2\vec{r_2}}{m_1 + m_2}$$

For a rigid body having continuous mass distribution.

$X_{CM} = \frac{\int x\,dm}{\int dm}$; $Y_{CM} = \frac{\int y\,dm}{\int dm}$ and

$$Z_{CM} = \frac{\int z\,dm}{\int dm}.$$

- When external forces act on system become zero, then the centre of mass of the system may be either at rest or in uniform motion in a straight line.

Ex:

i) If a bomb at rest explodes into no. of pieces the centre of mass remains stationary since forces involved are action – reaction pairs which are internal forces.

ii) A bomb is dropped freely from certain height. After some time exploded into no. of pieces. Then the path of the centre of mass of the bomb after explosion is a vertical straight line.

iii) If a shell is projected at an angle with the horizontal exp -lodes in mid air, the centre of mass continues to move with same parabolic path till anyone fragment reaches the ground.

iv) Two bodies of masses m_1 and m_2 are separated by a dis - tance d and initially they are at rest. Now they move tow- ards each other under mutual force of attraction. The velocity of centre of mass when they collided is zero.

v) If two bodies coupled by a string are pulled apart and released. The velocity of centre of mass is zero.

vi) A boat is floating on water surface. A man travels from one end of the boat to its other end. Then the centre of mass of the system is unchanged since the forces involved are internal forces.

vii) A person of mass m is standing on a boat of mass M so that he is d metre from shore. If he walks / metre on boat towards the shore then

a) The distance travelled by the boat in opposite direction

$$(d^1) = \frac{ml}{M+m}.$$

b) The distance of person from shore $= d + d^1 - l$.

- The motion of centre of mass can be determined using Newton's second law, $\vec{F} = m\vec{a}$.

Velocity of Centre of mass:

- If different particles of masse s m_1 , m_2, m_3 ……m_n move with velocities $\vec{v}_1$, $\vec{v}_2$, $\vec{v}_3$… …$\vec{v}_n$ respectively, then the velocity of the centre of mass is given by

$$\vec{V}_{CM} = \frac{m_1\vec{v}_1+m_2\vec{v}_2+m_3\vec{v}_3+\cdots+m_n\vec{v}_n}{m_1+m_2+m_3+\cdots+m_n}$$

$$= \frac{\Sigma m\vec{v}}{\Sigma m} \text{ or } \vec{V}_{CM} = \frac{\vec{P}}{M}$$

- Where P is total momentum of 'n' particles 'M' is total mass of 'n' particles.

Note: The velocity of centre of mass remains constant when no external force acts on the system.

- When two particles of masses m1 and m_2 are moving at right angles to each other with velocities v_1 and v_2, then the velocity of their centre of mass is given by

$$V_{CM} = \sqrt{\frac{m_1^2v_1^2+m_2^2v_2^2}{(m_1+m_2)^2}}$$

- (a) If v_1 and v_2 are the velo cities of particles of masses m1 and m2 moving in the same direction then the velo city of centre of mass of the system is

$$V_{CM} = \frac{m_1v_1+m_2v_2}{m_1+m_2}$$

(b) If they move in opposite dire -ction then $V_{CM} = \frac{m_1v_1-m_2v_2}{m_1+m_2}$

The total momentum of all the particles with respect to the centre of mass is zero.

Acceleration of Centre of mass:

- If different particles of masses m_1, m_2, m_3 ….. m_n move with acceleration $\vec{a}_1$, $\vec{a}_2$, $\vec{a}_3$……$\vec{a}_n$ respectively, then the acceleration of the centre of mass is given by

$$a_{CM} = \frac{m_1\vec{a}_1+m_2\vec{a}_2+m_3\vec{a}_3+\cdots+m_n\vec{a}_n}{m_1+m_2+m_3+\cdots+m_n}$$

$$= \frac{\Sigma m\vec{a}}{\Sigma m}.$$

- $\vec{F}_{external} = \vec{F}_1 + \vec{F}_2 + ...\vec{F}_n = M\vec{a}_{CM}$.

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