PHYSICS

CLASS NOTES FOR CBSE

Chapter 06. Laws on Motion

01. First Law of Motion

If the (vector) sum of all the farces acting on a particle is zero then and only then the particle remains unaccelerated (i.e., remains at rest or moves with constant velocity).

If the sum of all the forces on a given particle is $\vec{F}$ and its acceleration is $\vec{a}$, the above statement may also be written as

“ $\vec{a}=0$ if and *only* if $\vec{F}=0$“.

Thus, if the sum of the forces acting on a particle is known to be zero, we can be sure that the particle is unaccelerated, or if we know that a particle is unaccelerated, we can be sure that the sum of the forces acting on the particle is zero.

02. Inertial Frames other than Earth

Suppose *S* is an inertial frame and *S*’ a frame moving uniformly with respect to *S*. Consider a particle *P* having acceleration $\vec{a}_{p,s}$ with respect to S and $\vec{a}_{p,s'}$ with respect to *S*’.

We know that,

$$\vec{a}_{p,s} = \vec{a}_{p,s} + \vec{a}_{s',s}.$$

As *S*’ moves uniformly with respect to *S*,

$$\vec{a}_{s',s} = 0.$$

Thus, $\vec{a}_{p,s} = \vec{a}_{p,s'}$ ...(i)

Now *S* is an inertial frame. So from definition, $\vec{a}_{p,s} = 0$, if *F*=0 and hence, from (i), $\vec{a}_{p,s'} = 0$ if and only if $\vec{F}=0$.

Thus, *S*’ is also an inertial frame. We arrive at an important result : *All frames moving uniformly with respect to an inertial frame are themselves inertial.*

03. Free Body Diagram

No system, natural or man made, consists of a single body alone or is complete in itself. A single body or a part of the system can, however be isolated from the rest by appropriately accounting for its effect on the remaining system.

A free body diagram (FBD) consists of a diagrammatic representation of a single body or a sub-system of bodies isolated from its surroundings showing all the forces acting on it. Consider, for example, a book lying on a horizontal surface.

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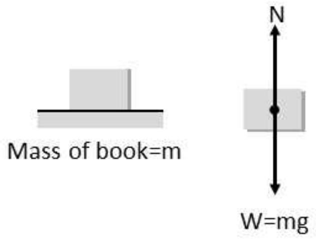
Consider, for example, a book lying on a horizontal surface.
A free body diagram of the book alone would consist of its weight ($W=mg$), acting through the centre of gravity and the reaction (N) exerted on the book by the surface.



04. Equilibrium

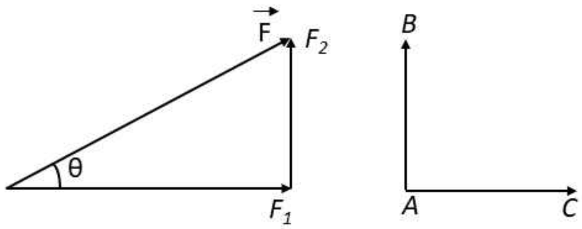
Forces which have zero linear resultant and zero turning effect will not cause any change in the motion of the object to which they are applied. Such forces (and the object) are said to be in equilibrium. For understanding the equilibrium of an object under two or more concurrent or coplanar forces let us first discuss the resolution of force and moment of a force about some point.

(a) Resolution of a Force

When a force is replaced by an equivalent set of components, it is said to be resolved. One of the most useful ways in which to resolve a force is to choose only two components (although a force may be resolved in three or more components also) which are at right angles also. The magnitude of these components can be very easily found using trigonometry.

In Fig. $F_1 = F\cos\theta$ = component of $\vec{F}$ along AC

$F_2 = F\sin\theta$ = component of $\vec{F}$ perpendicular to AC or along AB



Finding such components is referred to as resolving a force in a pair of perpendicular directions. Note that the component of a force in a direction perpendicular to itself is zero. For example, if a force of 10 N is applied on an object in horizontal direction then its component along vertical is zero. Similarly, the component of a force in a direction parallel to the force is equal to the magnitude of the force. For example component of the above force in the direction of force is equal to the magnitude of the force. For example component of the above force in the direction of force (horizontal) will be 10 N.

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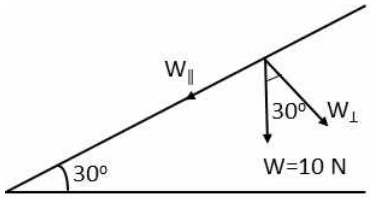
Example *Resolve a weight of 10 N in two directions which are parallel and perpendicular to a slope inclined at 30^o to the horizontal.*

Solution Component perpendicular to the plane

$$W_{\perp} = W \cos 30^o$$
$$= (10)\frac{\sqrt{3}}{2}$$
$$= 5\sqrt{5}\,N$$

and component parallel to the plane

$$W_{\parallel} = W \sin 30^o = (10)\left(\frac{1}{2}\right) = 5\,N$$



05. Moment of a Force

The general name given to any turning effect is **torque**. The magnitude of torque, also known as the moment of a force F is calculated by multiplying together the magnitude of the force and its perpendicular distance $r_{\perp}$ from the axis of rotation. This is denoted by C or τ (tau).

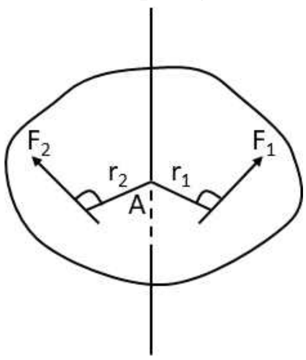
i.e., $C = Fr_{\perp}$ or $\tau = Fr_{\perp}$

Direction of Torque

The angular direction of a torque is the sense of the rotation it would cause.

Consider a lamina that is free to rotate in its own plane about an axis perpendicular to the lamina and passing through a point *A* on the lamina. In the diagram the moment about the axis of rotation of the force F_1 is F_1r_1 anticlock-wise and the moment of the force F_2 is F_2r_2 clockwise. A convenient way to differentiate between clockwise and anticlock-wise torques is to allocate a positive sign to one sense (usually, but not invariably, this is anticlockwise) and negative sign to the other.

With this convention, the moments of F_1 and F_2 are $+F_1r_1$ and $-F_2r_2$ (when using a sign convention in any problem it si advisable to specify the chosen positive sense).



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