The Newtonian Mechanics

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Outlines:

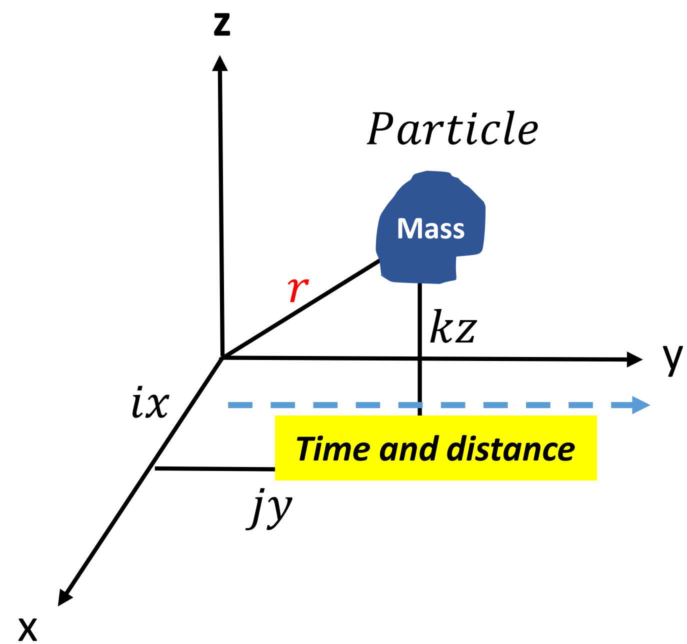
2.1 Introduction

Distance and Time ceoncept

Velocity and Acceleration of Particle

To discribe the ***MOTION of BODIES***

Distance | *Time* | *Mass*



$$Velocity = \frac{changing\ in\ distance}{changing\ in\ time}$$

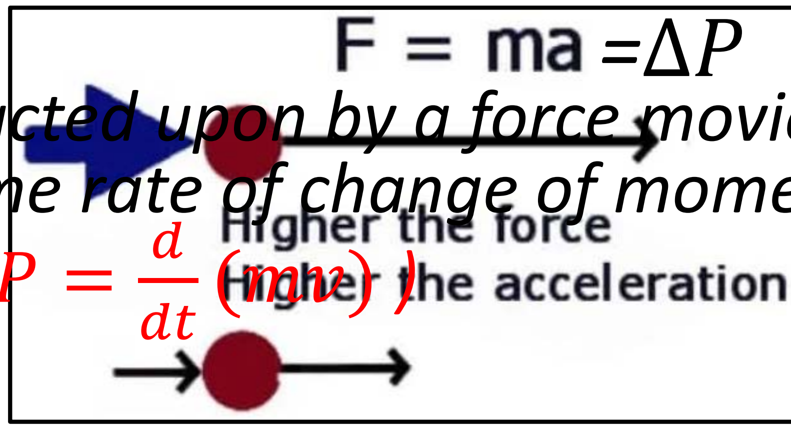
$$Acceleration = \frac{changing\ in\ velocity}{changing\ in\ time}$$

$$Momentum\ unit\ of\ \frac{mass\ X\ distance}{time}$$

$$Energy\ unit\ of\ \frac{mass\ X\ distance}{time}$$

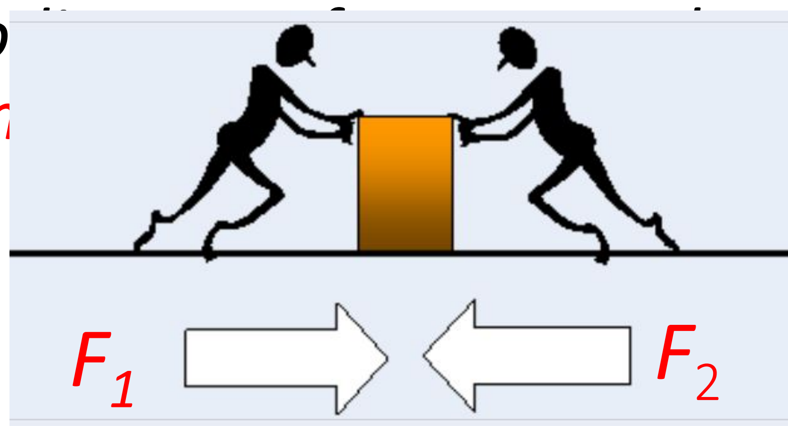
2.2 Newton's Law

1- A body remains at rest or in uniform motion unless acted upon by force. It is known as **Inertia**.



2- A body acted upon by a force movies in such a manner that the time rate of change of momentum equals the force. *(F=$\Delta P = \frac{d}{dt}(mv)$)*

3- If two bo … ther , these forces are equal ir … in direction.(F1=-F2)



2.2 Newton's Law

$$F_1 = -F_2 \quad \textit{From third law of Newton.}$$

$$\frac{dP_1}{dt} = -\frac{dP_2}{dt}$$ *from 2nd law of N.*

$$m_1 \frac{dv_1}{dt} = -m_2 \frac{dv_2}{dt}$$

$$m_1 a_1 = -m_2 a_2 \qquad as\ a = \frac{dv}{dt}$$

But m is positive quantity , so this mean the acceleration vectors are oppositely directed

2.2 Newton's Law

In regard , the body mass

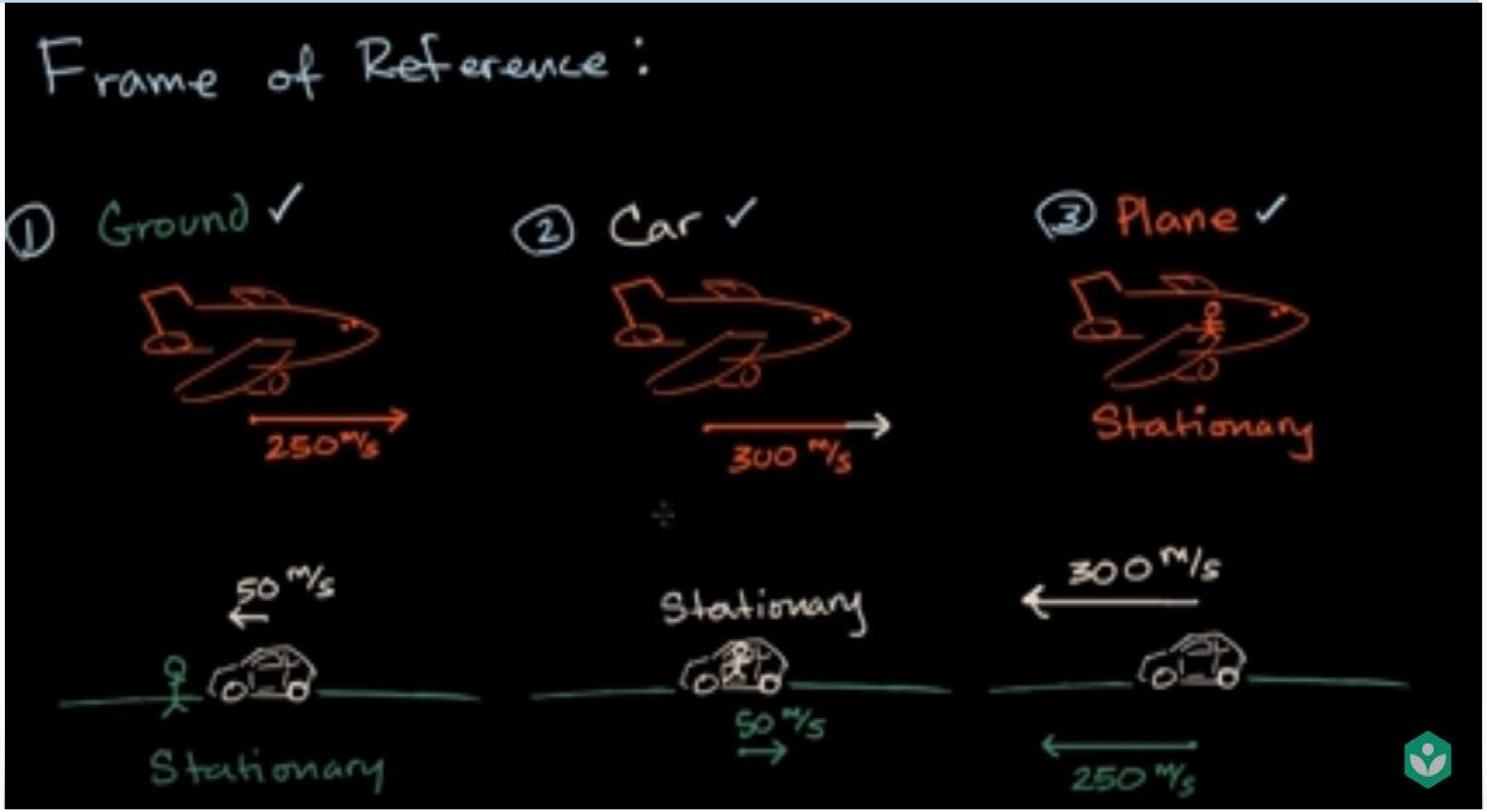
Inertial mass

$$F = ma$$

Gravitational mass

$$W = mg$$

2.3 Frames of References



https://youtu.be/3yaZ7lkQPUQ

2.4 Equation of Motion

Newton's equation $F = \frac{dp}{dt}$ can be expressed alternatively as :

$$F = \frac{d(mv)}{dt} = m\frac{dv}{dt} = m\ddot{r}$$

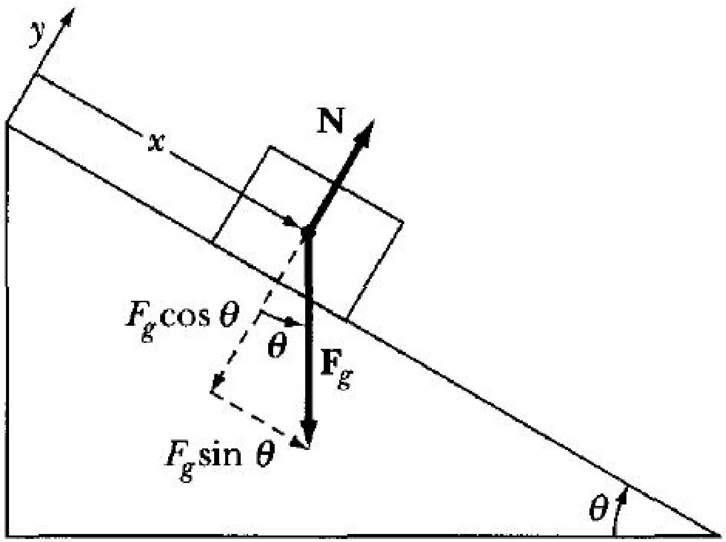
$F(r, v, t)$

$mass\ of\ a\ Partcle$

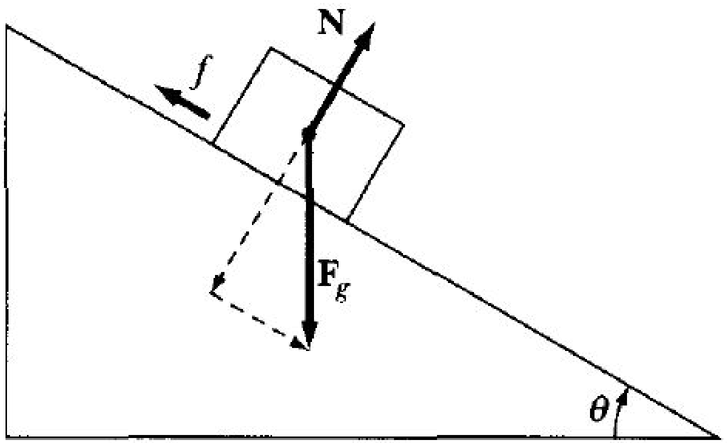
$Velocity\ of\ a\ Partcle$

Problem of Block Sliding

Let us first consider the problem of a block sliding on an inclined plane. Let the angle of the inclined plane be θ and the mass of the block be 100 g. The sketch of the problem is shown in Figure 2-2a.



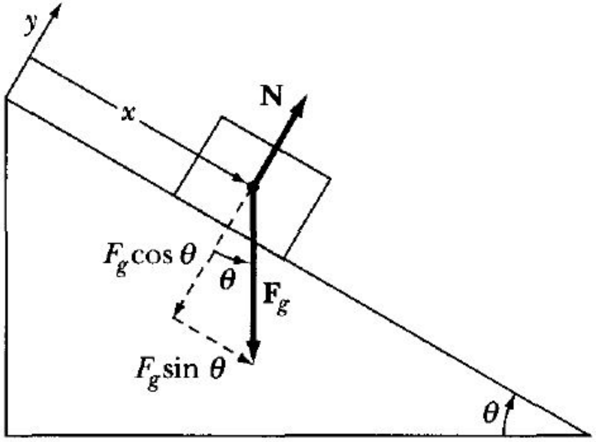
(a)



(b)

Example1:

If a block slides without friction down a fixed , inclined plane with $\theta = 30^{\circ}$, what is the block's acceleration ? Find the velocity of the block after it moves from rest to a distance x_0 down the plane?



(a)

Solution:

From the figure , there are two forces acting on the block

1- The gravitational force F_g.

2- The plane's normal force N pushing the block upward on the block.

So the total force is constant:

$$F_{net} = Fg + N$$

$$m\ddot{r} = Fg + N \qquad as\ , Fnet = m\ddot{r}$$

$This\ vector\ must\ be\ applied\ in\ two\ direction\ in\ x\ and\ y.$

$y - dirction \qquad -Fg\ cos\theta + N = 0 \qquad \dots\dots\dots.(1)$

$x - dirction \qquad Fg\ sin\theta = m\ddot{x} \qquad \dots\dots\dots.(2)$

$$\Rightarrow \ddot{x} = \frac{F_g}{m} sin\theta = g\ sin\theta \qquad as\ , Fg = mg$$

Example1:

$By\ multiply\ last\ equation\ 2\dot{x}$

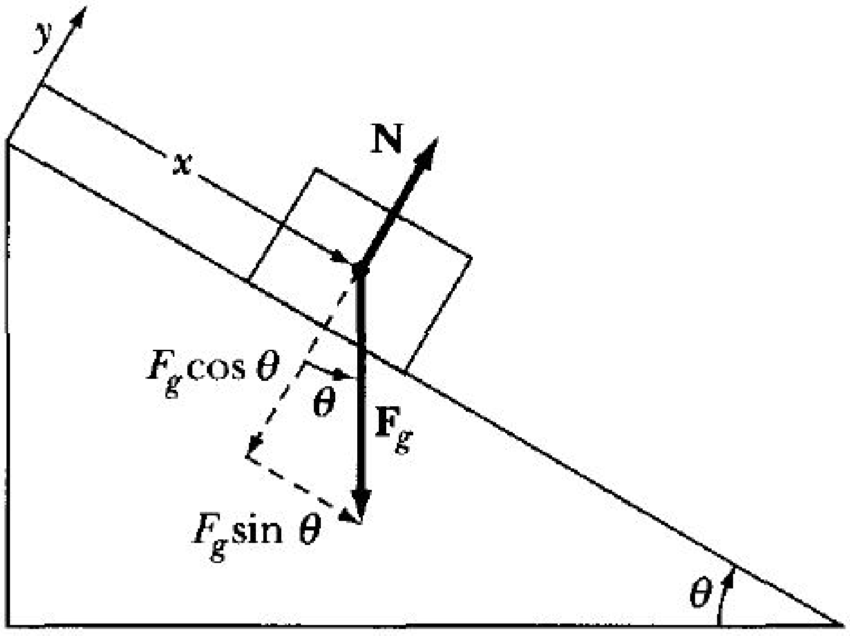
$$2\dot{x}\ddot{x} = 2\dot{x}\ g\ sin\theta$$

$$\frac{d}{dt}\dot{x}^2 = 2\ g\ sin\theta\ \frac{dx}{dt}$$

$$\dot{x}^2\Big|_0^{v_\circ} = 2\ g\ sin\theta\ \ x\Big|_0^{x_\circ}$$

$$v_\circ^2 = 2\ g\ sin\theta\ x_\circ$$

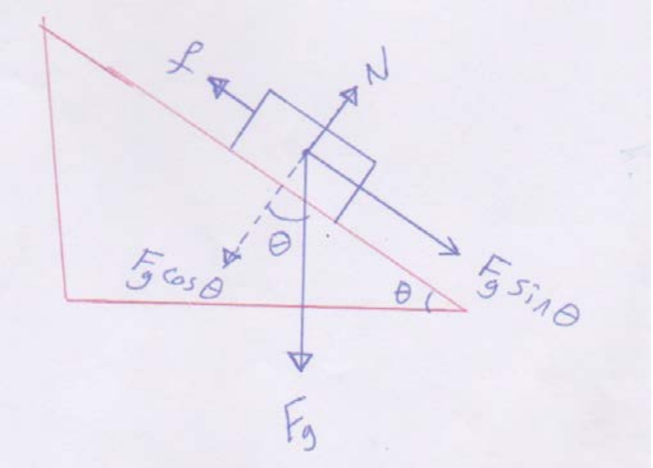
$$v_\circ = \sqrt{2\ g\ sin\theta\ x_\circ}$$



(a)

Example2:

Consider that the coefficient of static fraction between the block and plane in Example 1 is μ_s=0.4 , at which angle θ will the block start sliding if it is initially at reset.



Solution:

The static fractional force has the approximate Max. value

$$f_{max} = \mu_s N$$

$$F_{net} = Fg + N + f$$

$$m\ddot{r} = Fg + N + f \qquad as\,, Fnet = m\ddot{r}$$

This vector must be applied in two direction in x and y.

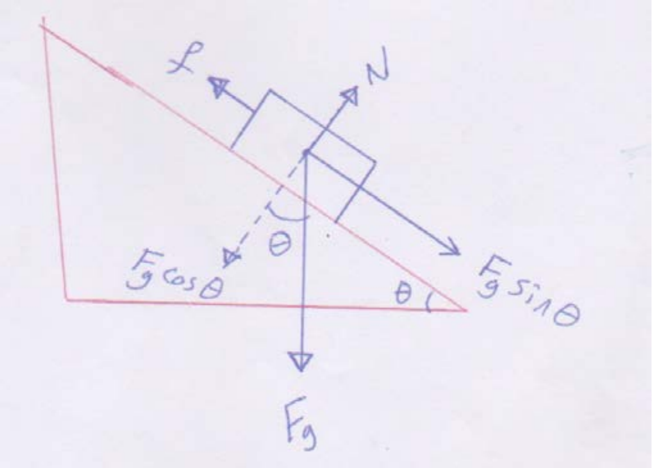
$x - dirction \qquad m\ddot{x} = F_g\, sin\theta - f \ldots\ldots\ldots .(3)$

$y - dirction \qquad 0 = -F_g \cos\theta + N \ldots\ldots\ldots .(4)$

As the angle increase , the static frictional force will be unable to keep the block at rest.

Example 2:

As the angle increase , the static frictional force will be unable to keep the block at rest.



$$f_s = fmax = \mu_s N \qquad \ldots\ldots\ldots.(5)$$

By substituting eq (5) in (2) and eq(4)

$$m\ddot{x} = F_g\,sin\theta - \mu_s F_g\,cos\,\theta \ldots \quad \ldots.(6)$$

$$\ddot{x} = g\,(sin\theta - \mu_s cos\,\theta) \ldots \quad \ldots.(7)$$

Just before the block starts to slide, the acceleration $\ddot{x} = 0$, *So*

$$sin\theta = \mu_s\,cos\,\theta \quad \ldots\ldots\ldots\ldots.\ldots.(8)$$

$$\mu_s = \frac{sin\theta}{cos\,\theta} = tan\,\theta \;\Rightarrow\; \theta = tan^{-1}\,\mu_s$$