Problem solving using Newton’s Laws of Motion

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A Block of mass m slides down an inclined plane as shown. Find its acceleration. \((g = 9.8 \text{ m/s}^2)\)
Objects at rest, such as a chair, desk, book, etc..., will not move by itself unless a force is placed on it.

AHHHH

... GHOST!!
Recall the three laws...

Newton’s First Law

- An object at rest remains at rest as long as no net force acts on it.
- An object moving with constant velocity continues to move with the same speed and in the same direction as long as no net force acts on it.
Recall the three laws...

Newton’s Second Law (for a single force)

\[ \text{force} = \text{mass} \times \text{acceleration} \]

\[ F = ma \]

Force is equal to mass times acceleration.
Recall the three laws...

Newton’s Third Law:
For Every action there is An equal and opposite Reaction
## Importance

<table>
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<tr>
<th>Law</th>
<th>Before</th>
<th>After</th>
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<tbody>
<tr>
<td>Newton’s First law (Law of Inertia)</td>
<td>Come to Rest</td>
<td>Continue the motion</td>
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<tr>
<td>Newton’s second law (Law of force)</td>
<td>Force required for motion</td>
<td>Force is required only to change state of motion</td>
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<tr>
<td>Newton’s third law (Law of interaction)</td>
<td>Single force exists</td>
<td>Forces are always in pair</td>
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</table>
Applying Newton’s Laws

- Four Steps:
  1) **Decide** the System
  2) **Identify** the forces acting
  3) **Free body diagram**
  4) **Simplification** and solving
System

• A system is
  a single particle or group of particles
  a single body or group of bodies
  in contact with each other or connected by inextensible string

Provided

  The acceleration of every part of system should be same.
Forces

• Enlist the forces acting on the System only

- Weight or gravitational force Always vertically downward
- Normal reaction perpendicular to surface
- Frictional force opposite to motion
- Tension along string
Free body diagram

• **Representation** of System Free from its structure and surrounding.

For This

- Replace/Represent system by *single point*
- **Draw vectors** according to magnitude and direction of forces *from the point*
- **Draw Cartesian co ordinate axes** from the point as origin
Simplification and Solving

• Find **rectangular components** of Forces according to vector analysis along the axes

• Take **sum** of forces along the axes

  \[ \Sigma(F_x), \Sigma(F_y), \Sigma(F_z). \]

• If motion is along x axis then

  \[ \Sigma(F_x) = m \cdot \text{acc} \]

• For other axes \( \Sigma(F_y) = 0, \Sigma(F_z) = 0. \)
Step 1- The **Block** is a system

Step 2- The forces acting on system are:

a) Gravitational Force (**Weight**) of system acting vertically downward

b) Normal reaction **N** inclined at angle $\theta$ with respect to Vertical direction

c) **Frictional force** $f$ opposite to motion along a line making angle $\theta$ w. r. to Horizontal direction (For Frictionless surface $f=0$)
Step 3 - Free body diagram and Simplification
Writing Equations & Simplification

- The X axis is taken along Inclined line hence
  \[ \Sigma(F_x) = mgsin\theta - f = m*acc \]
  hence \[ \Sigma(F_y) = N - mgcos\theta = 0 \]
  \[ \Sigma(F_z) = 0. \]

Solving we get
  \[ acc = gsin\theta \ldots \text{ (f=0 for frictionless surface)} \]
  using \( g=9.8 \) m/s\(^2\) and
  Value of \( \theta \)
  calculate acceleration of block.
  If Inclination angle is \( 30^0 \) then
  \[ acc = 9.8*\sin(30) \]
  \[ acc = 9.8* (0.5) \]
  \[ acc = 4.9 \text{ m/s}^2 \]
Solve
Thank You