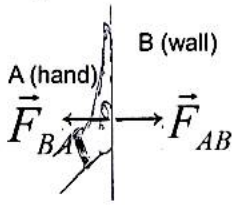
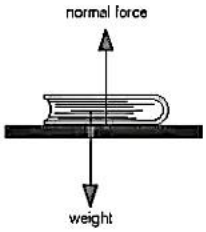
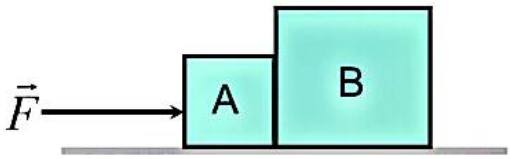
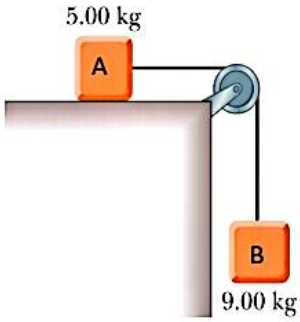
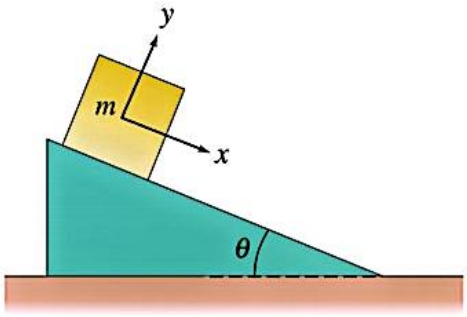
3.4 Newton's Laws of Motion

LO 3.4 a) State Newton's Law of Motion

Newton's Law	Definition	Example
First	An object at rest will remain at rest, or continues to move with uniform velocity in a straight line unless it is acted upon by an external force.	**Inertia** concept : • defined as **the tendency of an object to resist any change in its state of rest or motion.** • is a scalar quantity. • If the mass of a body increases then its inertia will increase. **Equilibrium** concept : • No resultant forces $\sum F = F_{net} = 0$ $\left(\sum F_x = 0, \sum F_y = 0\right)$
Second	The **rate of change of linear momentum** of a moving body is **proportional** to the **net force/resultant force** and is in the same direction as the force acting on it.	$\sum F = F_{net} = ma$ • $\sum F$ is net force or total force (N) • m is mass (kg) • a is acceleration (ms^{-2}) ***a*** **is zero** for object in **stationary, at rest, at static equilibrium** or moving with **constant velocity (dynamic equilibrium) → 1st Law**
Third	**Every action force has a reaction force** that is **equal in magnitude** but **opposite in direction**	**Action reaction** example : (i) When you push on the wall, it will push back with the same force.  $F_{AB} = -F_{BA}$ F_{BA} is also called Normal Force (ii) When a book is placed on the table, the normal force (force by table on book) is the reaction of the force the book exerts on the table (weight). 

Example 8

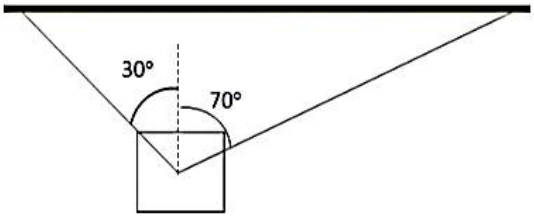
Using the equation in Newton's Second Law, write the expression of total (resultant) force for each of the cases below and determine whether the object is at equilibrium or not.

(a) An object lies at rest on a flat horizontal surface	(b) An object lies at rest on a rough inclined plane
(c) Lift moving upward at a uniform velocity	(d) Lift moving upwards at a constant acceleration, a
(e) Lift moving downwards at a constant acceleration, a	(f) Two blocks, A and B are side by side. They are pushed along a smooth floor under the action of a constant force F applied to A as shown in the figure. Is the value of acceleration A and B equal? 
(g) The system is released from rest and moving with constant acceleration, a. 	(h) A box is released from rest and moving with constant acceleration, a. 

LO 3.4 b) Apply Newton's Law of Motion

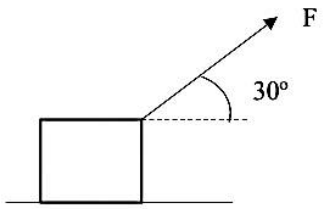
Example 9

An object of weight W = 49 N is suspended by two strings which are at 30° and 70° to the vertical as shown below. The object is in **equilibrium.** Calculate the tension in each string. **[Answer : 24.88 N; 46.76 N]**



Example 10

A 10.0 kg box is pulled along a horizontal rough surface by a force, $F = 40$ N applied at a 30° angle above horizontal.



Calculate :

a) The magnitude of normal force exerted by the table on the box. **[Answer : 78.1 N]**

b) Acceleration of the box if the coefficient of kinetic friction is 0.3. **[Answer : 1.12 ms^{-2}]**