

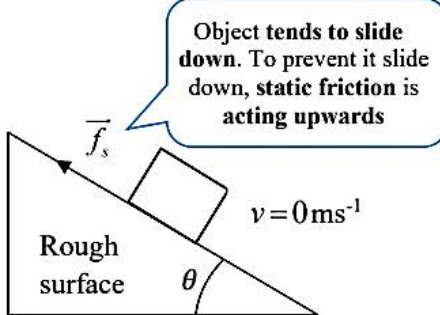
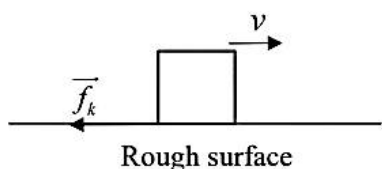
3.3 Basic of Forces and Free Body Diagram

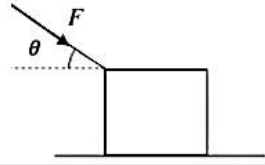
LO 3.3 a) Identify the forces acting on a body in different situations

a) Type of Forces

- Force is a vector that causes an object to move, stop, change its direction or change its shapes.
- The SI unit for all forces is Newton (N) or kg m s^{-2} .
- There are many forces we will deal with over and over. Table below shows some of them.

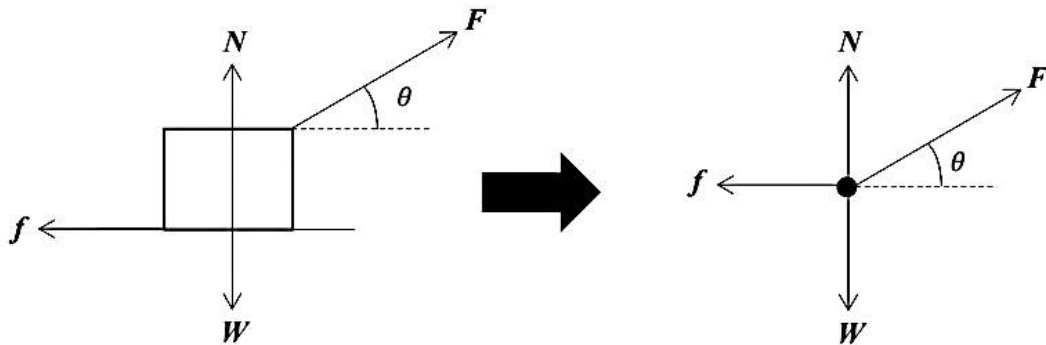
Force	Explanation	Diagram
Weight, W	<ul style="list-style-type: none"> Force exerted on a body under gravitational field on or near the surface of the earth. Equation: $\vec{W} = m\vec{g}$ W: Weight force ; m: mass g: gravitational acceleration (9.81ms^{-2}) Direction: points vertically downward and always perpendicular to the ground. 	
Tension, T	<ul style="list-style-type: none"> Tension force exists when there is string/rope/wire/cable/chain etc. Direction : in the direction of the string and always away from the object that being pulled and along the string. Same string possessed same tension. 	
Normal, N	<ul style="list-style-type: none"> Reaction force that is exerted by the surface to an object in contact with the surface. The agent for the normal force is the contact surface. Direction : always perpendicular to the contact surface and outwards of an object. 	

Force	Explanation	Diagram
Friction, f	<ul style="list-style-type: none"> Force that opposes the relative motion of two (rough) surfaces in contact. In our syllabus, the surface is always smooth unless stated rough surface. Friction is directly proportional to the reaction force. $f \propto N$ Equation : <div style="border: 1px solid black; padding: 10px; width: fit-content; margin: 10px auto;"> $\vec{f} = \mu \vec{N}$ </div> <p>Where :</p> <p>\vec{f} : friction force μ : coefficient of friction \vec{N} : Normal force</p> <ul style="list-style-type: none"> Coefficient of friction, μ is defined as the ratio between frictional force to normal force. μ depends on the nature of the surface. There are two types of friction : <ul style="list-style-type: none"> i) Static friction, \vec{f}_s ii) Kinetic friction, \vec{f}_k $\mu_s > \mu_k \text{ and } \vec{f}_s > \vec{f}_k$ The kinetic friction is less than static, because it takes more effort to start sliding something than to keep it sliding. 	<p>Static friction, f_s</p>  <p>a) Static friction is the force that keeps an object “stuck” on a surface and prevent it from moving. (frictional force before the object start moving, $v = 0 \text{ ms}^{-1}$)</p> <p>b) Direction : It points opposite the direction of tendency of motion. (it points in the direction to prevent the motion)</p> <p>c) Keywords use in exam : - When the object is about to move - When the object starts to move - Just before the object begins to move</p> <p>Kinetic friction, f_k</p>  <p>a) Kinetic friction appears as an object moves across a surface.</p> <p>b) This is a force that “opposes the motion”.</p> <p>c) Direction : It points opposite direction to the velocity (“the motion”).</p>

Force	Explanation	Diagram
External Force	<p>External force is a push or a pull on the object.</p> <p>Direction : Any direction depends on the situation given in the question.</p>	<p>Example : Figure below shows a 500 N force, F act on a stationary box at an angle of θ :</p> 

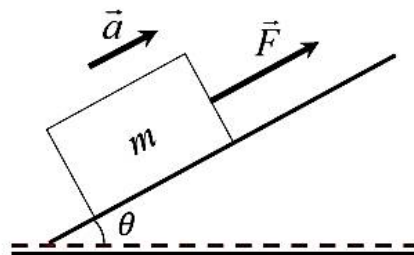
LO 3.3 b) Sketch free body diagram

- a) A **free body diagram** represents an object as a **particle (or dot)** and it shows all the forces acting on the object.
- b) Example of free body diagram :
 A box of mass m is pulled along a horizontal surface by a force F , applied at an angle θ above the horizontal. Assume that the surface is **rough**.

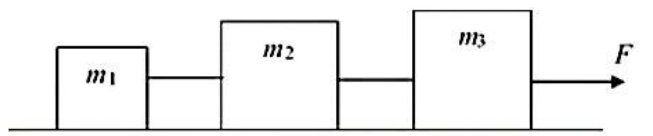


Example 6

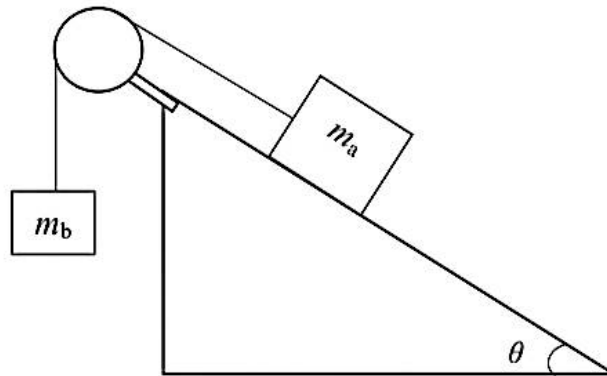
- a) Identify all forces acting in each of the situation below.
- i) A box is pulled up along a rough inclined plane by force, F .



- ii) Three blocks of masses m_1 , m_2 and m_3 are connected by strings and pulled by a force F on a **smooth** horizontal surface.



- b) A box of mass m_a rest on a **rough** surface inclined at θ to the horizontal. The system is at rest. Assume $m_b > m_a$.



LO 3.3 c) Determine static and kinetic friction

Static Friction, f_s	Kinetic Friction, f_k
Both forces oppose the relative motion between two rough surfaces which are in contact	
<ul style="list-style-type: none"> exists when object in contact is not moving/ stationary. If the object is not moving, the total (net) force acted on the object is zero. $\sum F = F_{net} = 0$ 	<ul style="list-style-type: none"> exists when object in contact is moving. If the object is moving with constant velocity, the total (net) force acted on the object is zero. $\sum F = F_{net} = 0 \text{ (constant velocity)}$ If the object is moving with constant acceleration, the total (net) force acted on the object is : $\sum F = F_{net} = ma \text{ (constant acceleration)}$

Example 7

A 3.0 kg cube is placed on a rough plane as shown in the figure. The plane is then slowly tilted until the cube starts to move from rest. This occurred when the angle of inclination is 25° . Calculate the **static frictional force** between the cube and the rough plane.

[Answer : 12.44 N]

