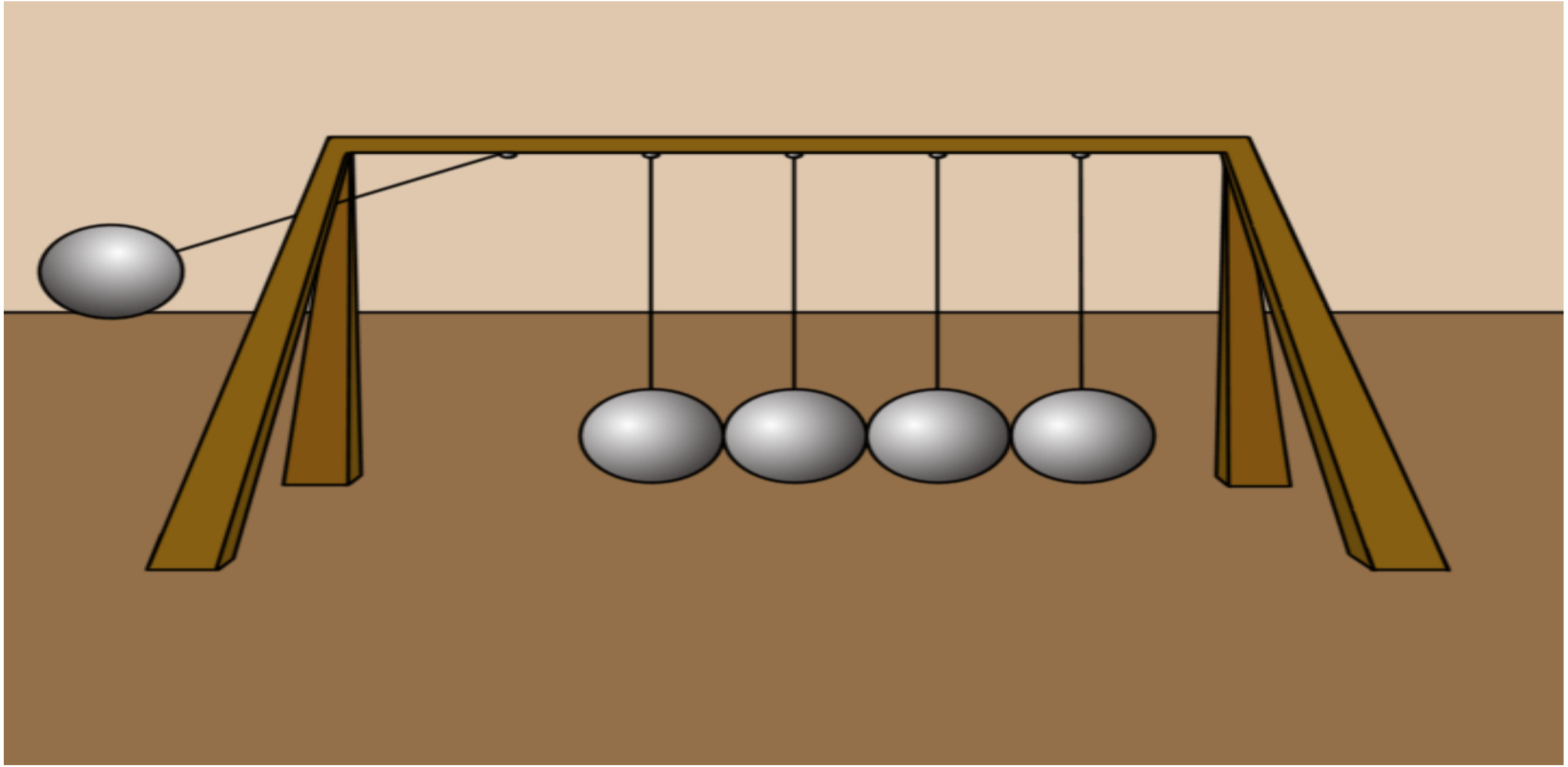
Law Of Motion

- By Saurabh sir



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1. FIRST LAW OF MOTION

According to this law, every body continues in its state of rest or motion in a straight line unless it is compelled by external force to change that state.

(i) *This law is also called law of inertia. Inertia is a virtue by which a body opposes the state of rest or motion.*

(ii) *Force is such a factor, which is essential for change in translatory motion of a body.*

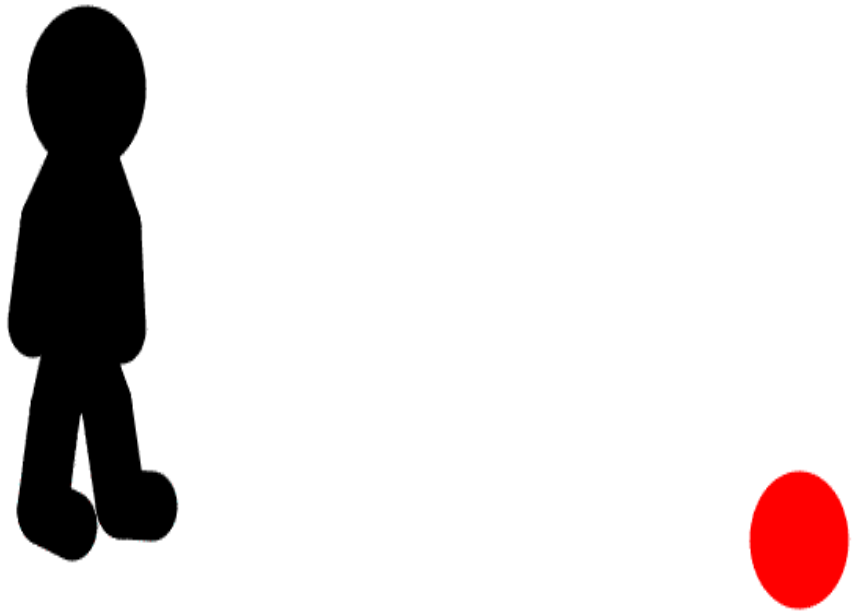
(iii) *The first law of motion defines the force.*

1. मोशन का पहला नियमइस कानून के अनुसार, प्रत्येक शरीर एक सीधी रेखा में अपने आराम या गति की स्थिति में रहता है जब तक कि उस स्थिति को बदलने के लिए बाहरी बल द्वारा मजबूर नहीं किया जाता है।

(i) इस कानून को जड़ता का कानून भी कहा जाता है। जड़ता एक गुण है जिसके द्वारा एक शरीर आराम या गति की स्थिति का विरोध करता है।

(ii) बल एक ऐसा कारक है, जो किसी निकाय की लिप्यंतरण गति में परिवर्तन के लिए आवश्यक है।

(iii) गति का पहला नियम बल को परिभाषित करता है।



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2. SECOND LAW OF MOTION

According to this law, the rate of change of momentum (mass × velocity) of a body is proportional to the impressed force and it takes place in the direction of the force.

Mathematically, $F \propto \frac{dP}{dt}$

$$F = k\frac{dP}{dt}$$

$$F = m\frac{dV}{dt}$$

$$F = ma$$

2. मोशन का दूसरा नियम

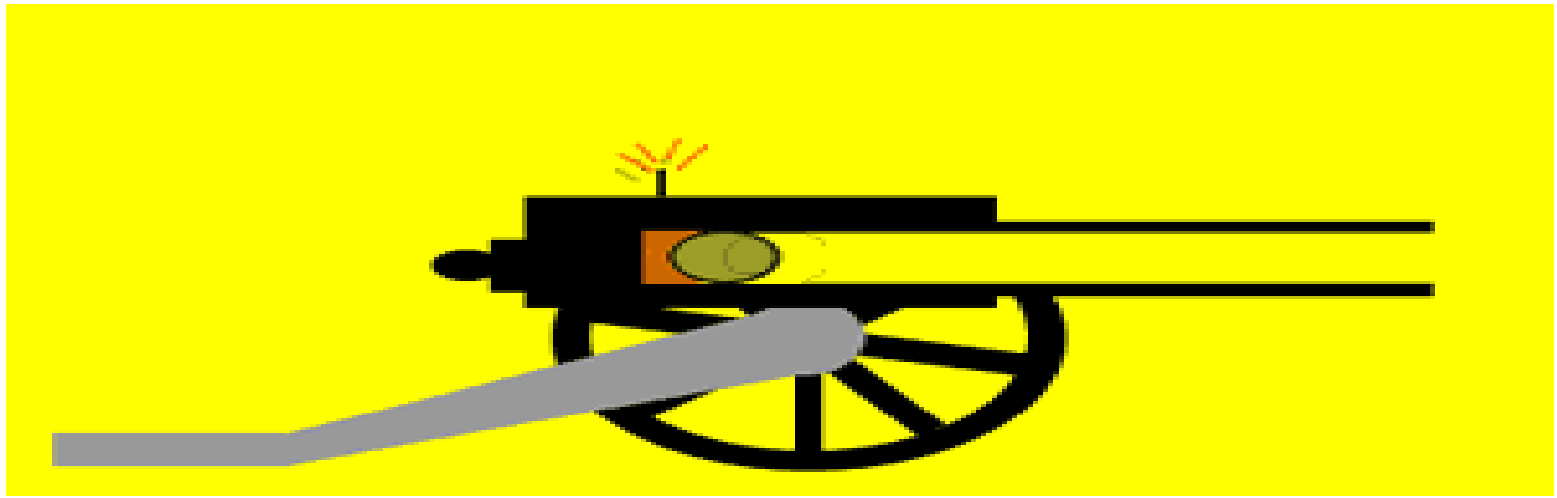
इस कानून के अनुसार, किसी पिंड के संवेग (मास × वेग) के परिवर्तन की दर प्रभावित बल के समानुपाती होती है और यह बल की दिशा में होती है।

3. THIRD LAW OF MOTION

According to this law, 'Every action has its equal and opposite reaction"

3. मोशन का तीसरा नियम

इस कानून के अनुसार, 'प्रत्येक क्रिया की अपनी समान और विपरीत प्रतिक्रिया होती है



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Impulse:-

If a force acts on a body for a short duration Δt, then impulse is defined as product of force and its time of action

Impulse= Force × Duration

$$I = F \times \Delta t$$

$$I = \frac{\Delta P}{\Delta t} \times \Delta t$$

आवेग: -

यदि कोई बल किसी छोटी अवधि के लिए किसी निकाय पर कार्य करता है, तो आवेग को बल के उत्पाद और उसकी क्रिया के समय के रूप में परिभाषित किया जाता है

REFERENCE FRAMES

Whenever the observer is situated in space that is called the frame of reference. The reference frame is associated with a coordinate system and a clock to measure the position and of the events happening in space.

जब भी पर्यवेक्षक अंतरिक्ष में स्थित होता है जिसे संदर्भ का फ्रेम कहा जाता है। संदर्भ फ्रेम एक समन्वय प्रणाली और एक घड़ी के साथ जुड़ा हुआ है जो स्थिति और अंतरिक्ष में होने वाली घटनाओं को मापने के लिए है।

Frame of Reference

Whether or not you are moving depends on your point-of-view.

From inside the box car, the woman in red is stationary (at rest).

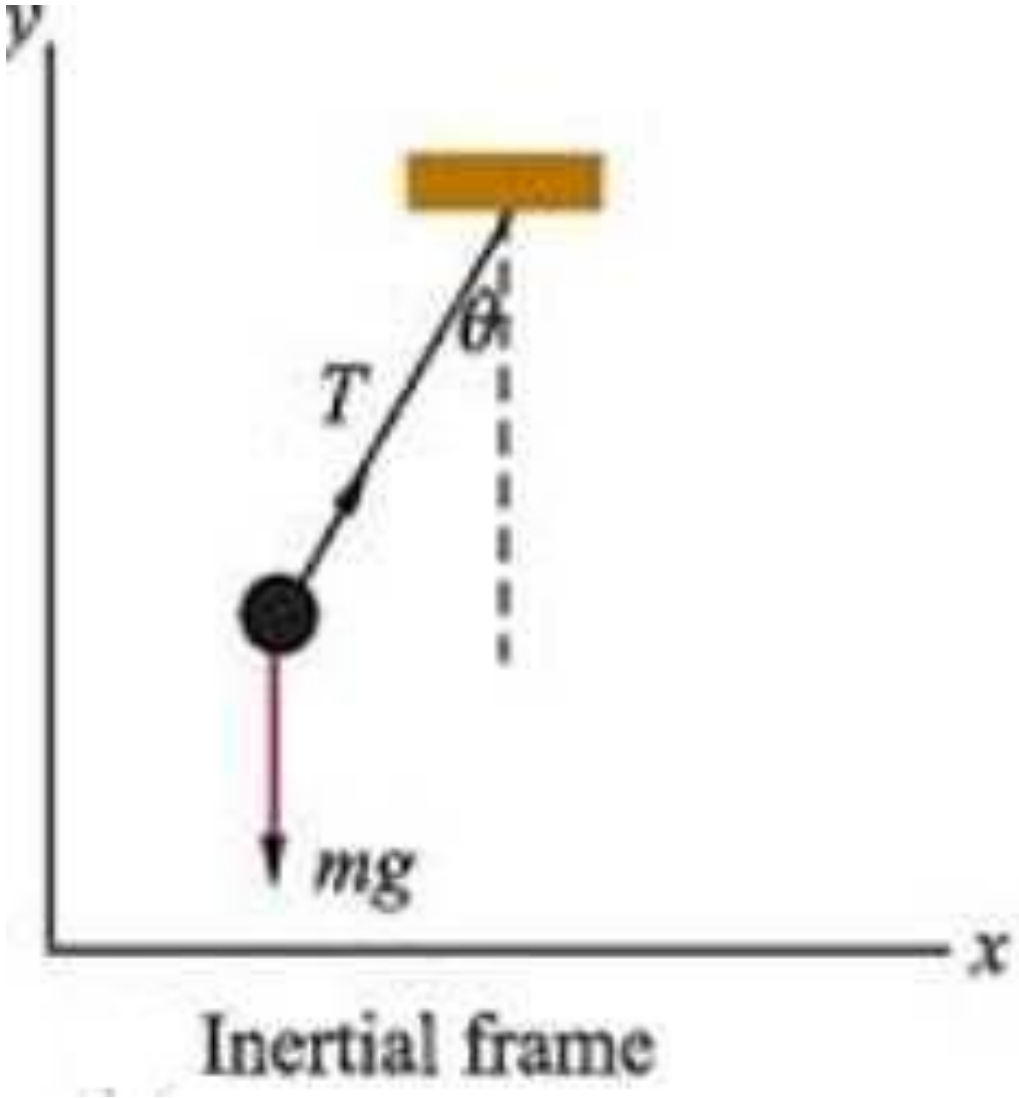
From outside the box car, the woman in red is moving.

So what is it? Is she moving? Is she stationary?

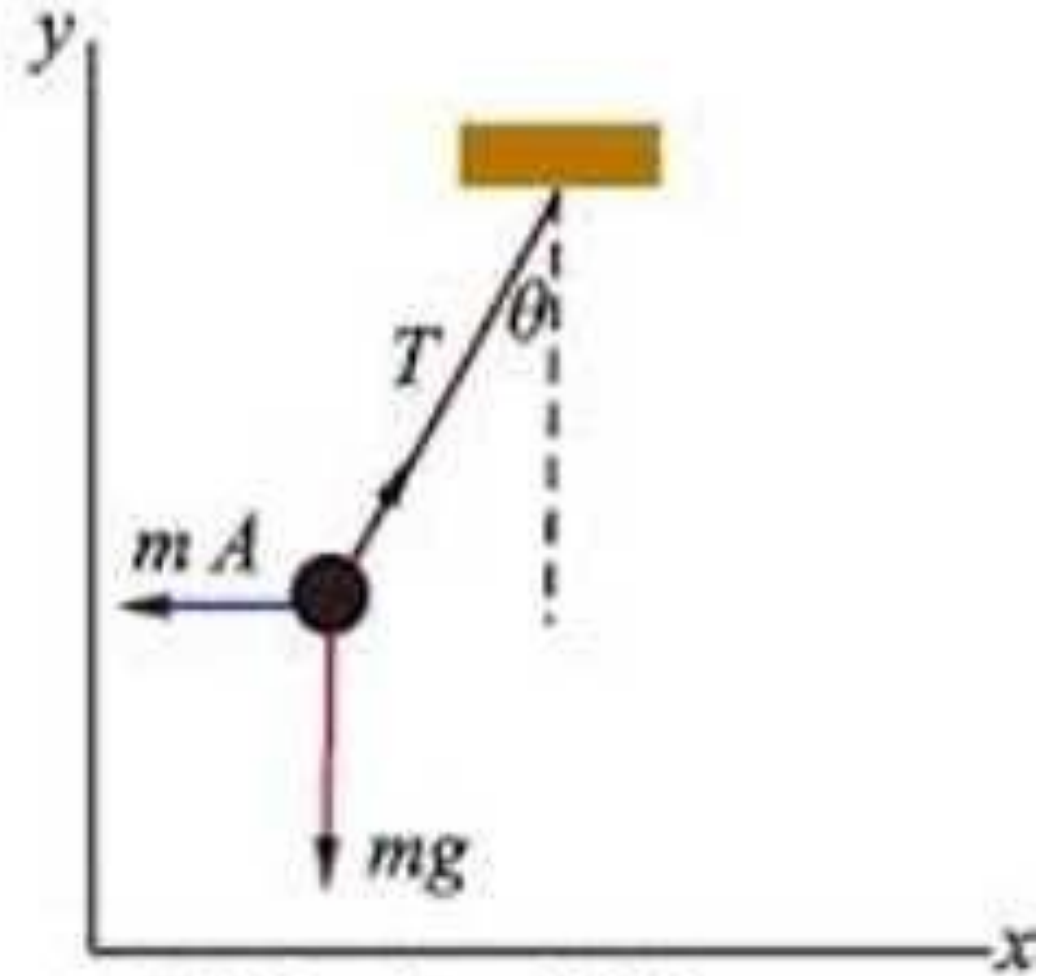
TYPES OF REFERENCE FRAME

a) Inertial frame of reference

b) Non-inertial frames of reference



Inertial frame



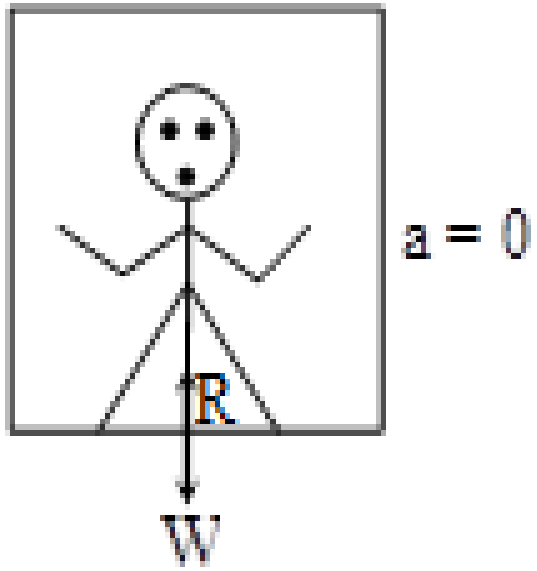
Noninertial frame

MOTION IN A LIFT

Weight :-The pull of earth on any body under its gravitational influence is called the weight of the body. This force is directed towards the centre of the earth. This force produces an acceleration on the body called the acceleration due to gravity

$$W=mg$$

भार: -इसके गुरुत्वाकर्षण प्रभाव के तहत किसी भी पिंड पर पृथ्वी के खींचने को कहा जाता है शरीर का वजन। यह बल पृथ्वी के केंद्र की ओर निर्देशित होता है। यह बल गुरुत्वाकर्षण के कारण त्वरण नामक शरीर पर त्वरण पैदा करता है

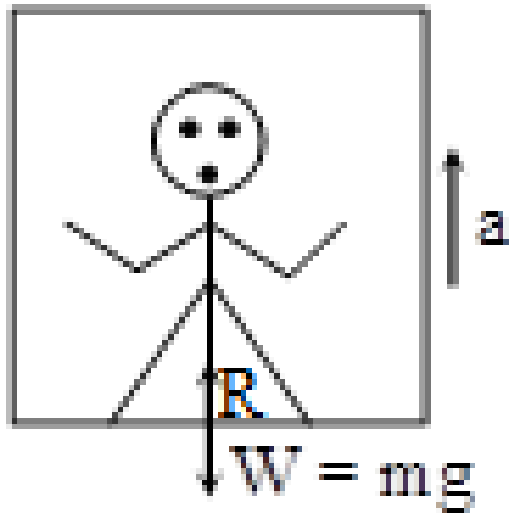


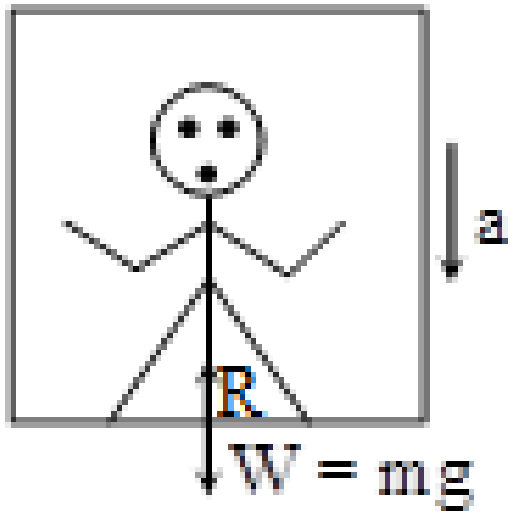
If the lift is unaccelerated

R = mg

If the lift is accelerated upward

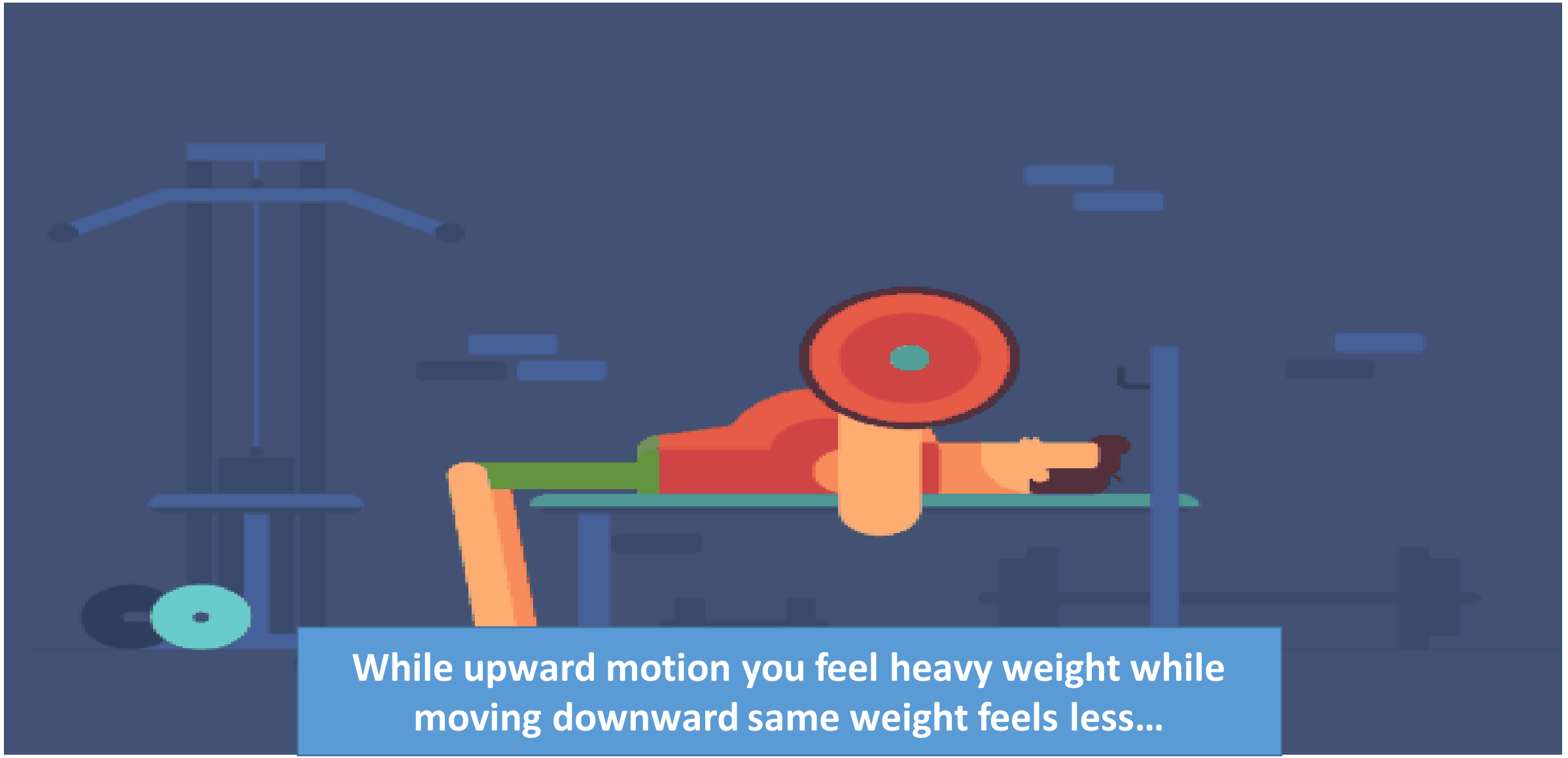
R = mg + ma





If the lift is accelerated downward

R = mg – ma



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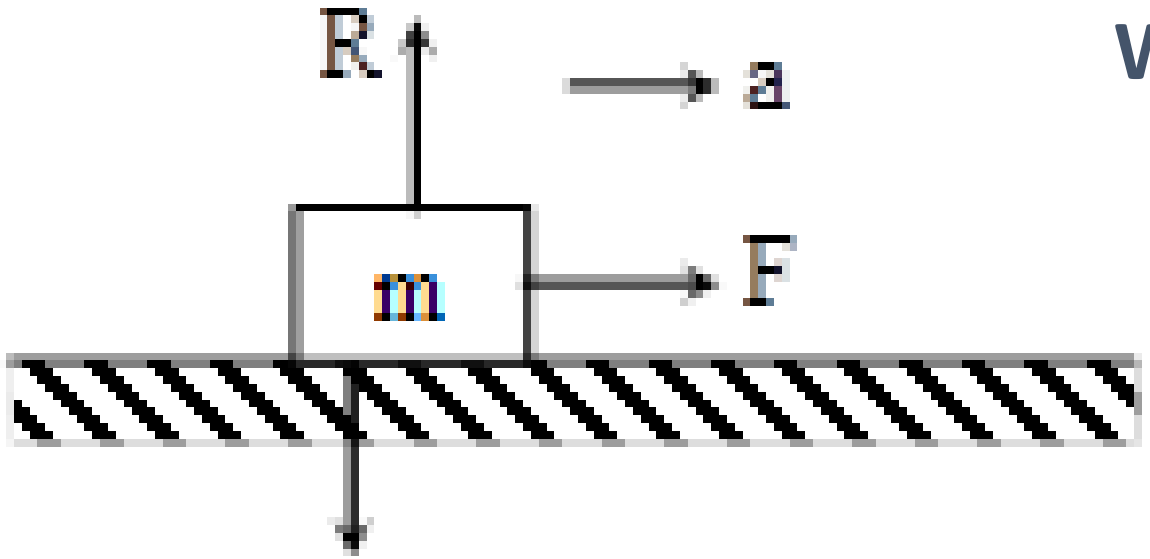
MOTION OF A BLOCK ON A HORIZONTAL SMOOTH SURFACE

a) When subjected to a horizontal pull

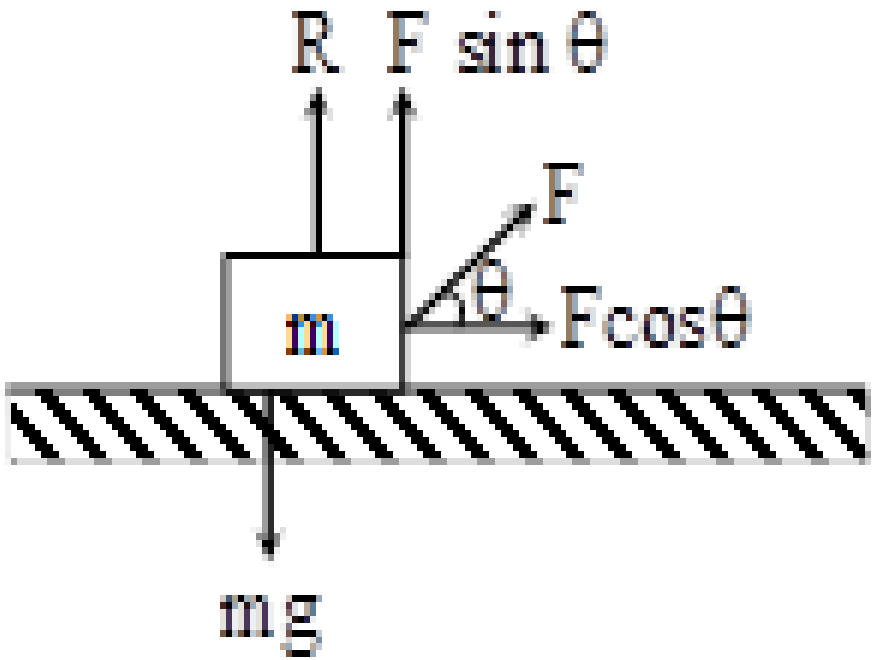


When subjected to a horizontal pull

$R = mg$

$F = ma$

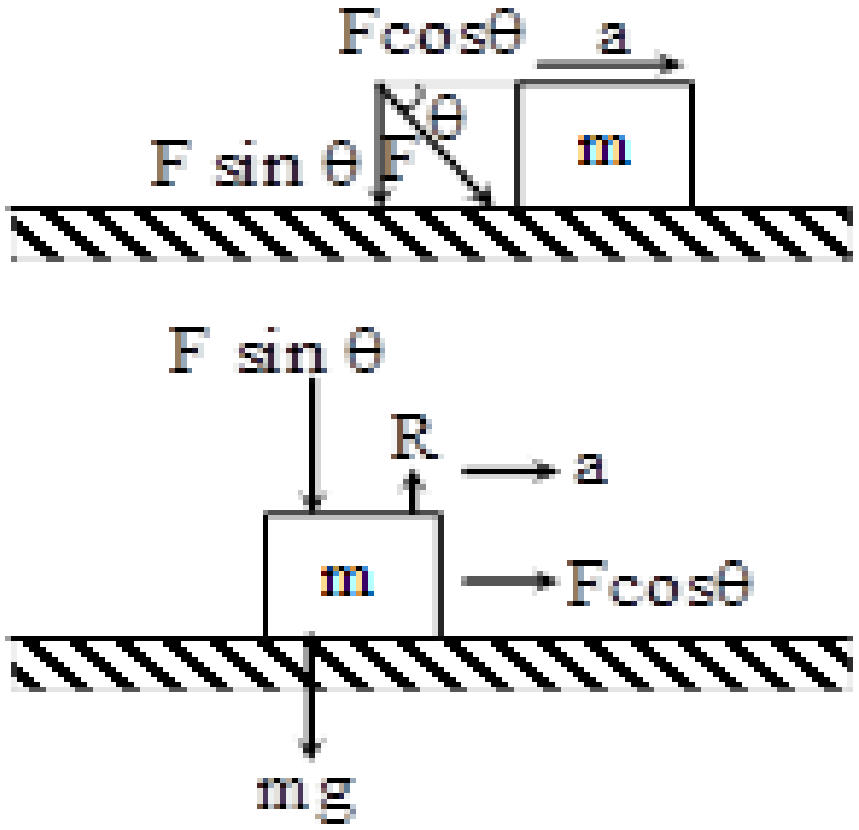
b) When subjected to a pull acting at an angle (θ) to the horizontal



$$R = mg - F \sin\theta$$

$$F \cos\theta = ma$$

c) When the block is subjected to a push acting at an angle θ to the horizontal : (downward)

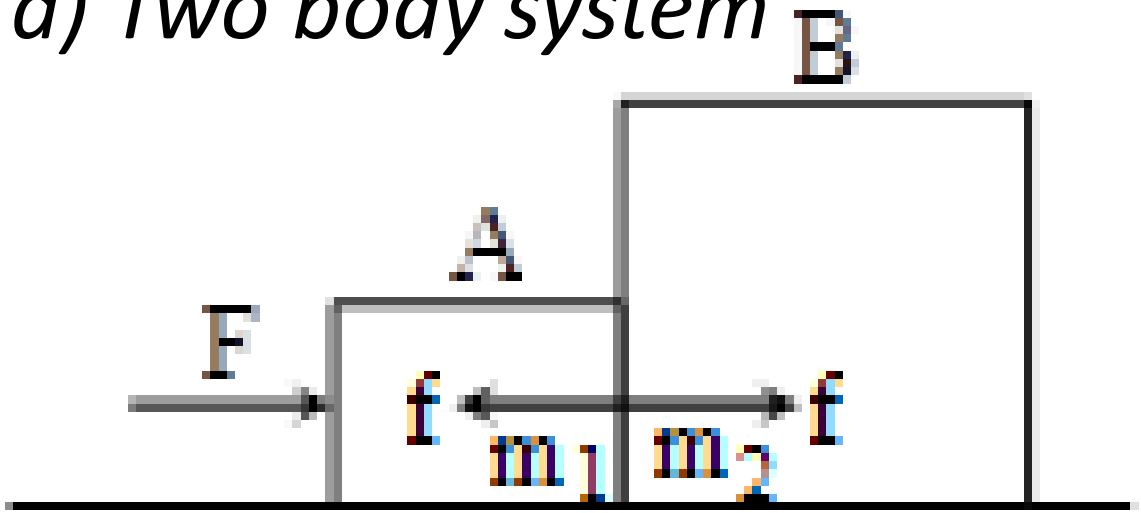


$$R = mg + F\sin\vartheta$$

$$F\cos\vartheta = ma$$

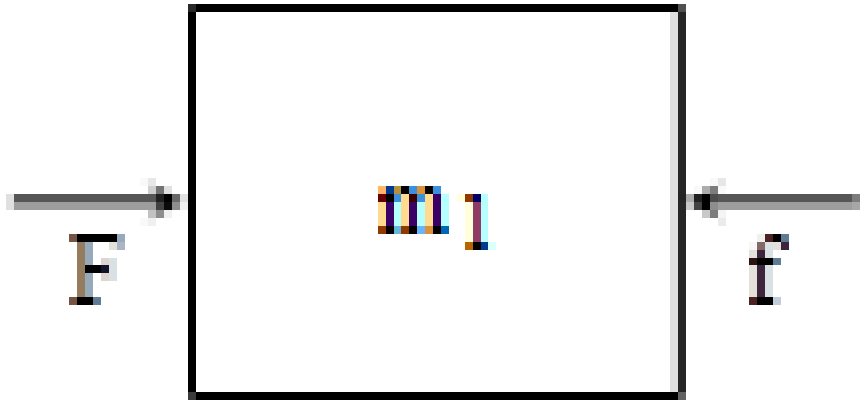
MOTION OF BODIES IN CONTACT

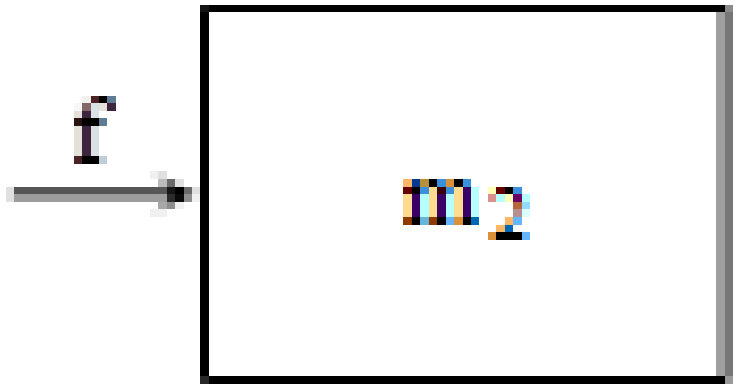
a) Two body system



$$F = (m_1 + m_2)a$$

$$f = \frac{m_1 F}{M_1 + M_2}$$



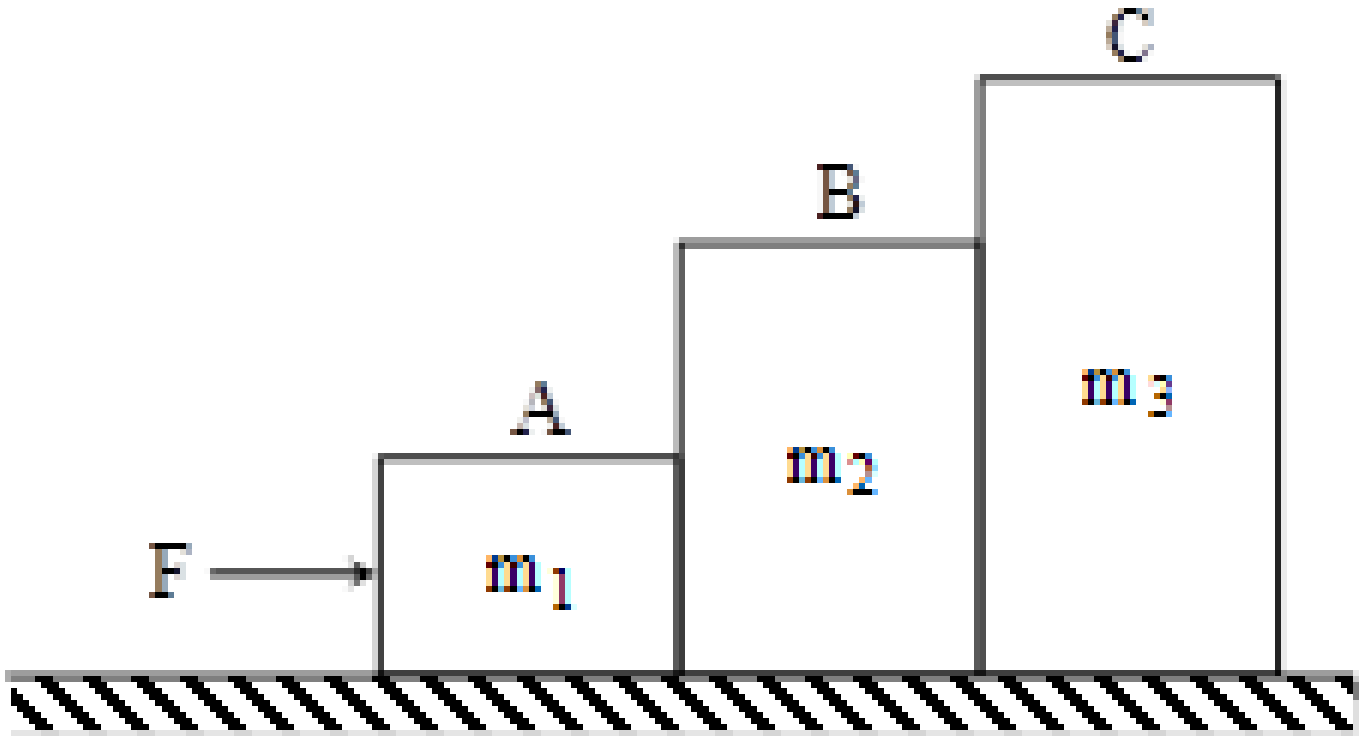


$$F - f = m_1 a$$

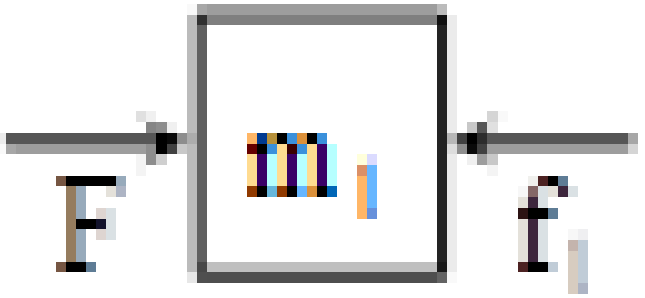
$$f = m_2 a$$

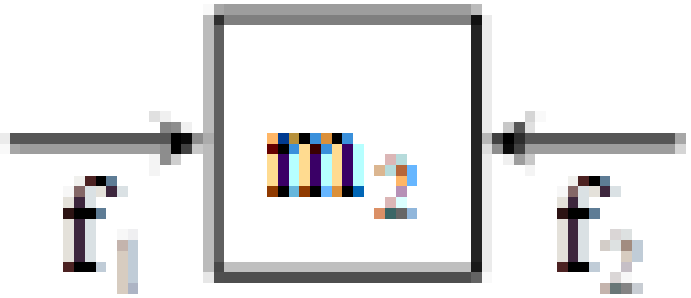
$$F = f + m_1 a$$

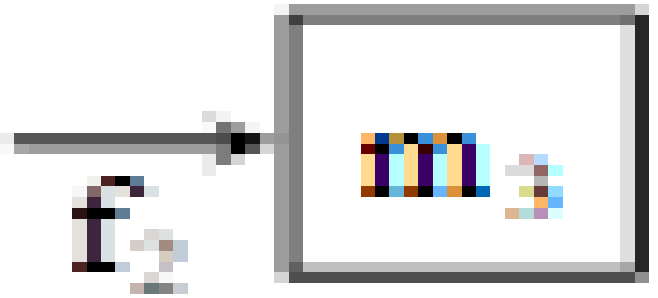
b) Three body system:-



$$a = \frac{F}{m_1 + m_2 + m_3}$$







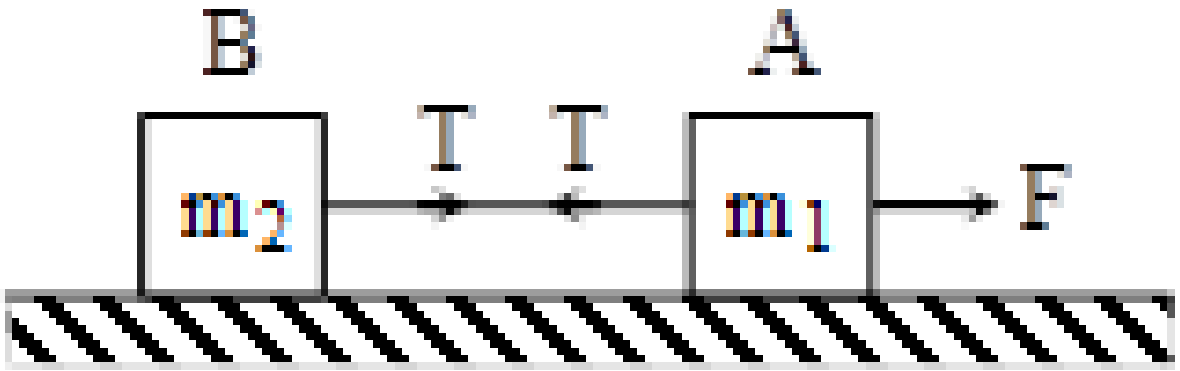
$$F - f_1 = m_1 a \qquad f_1 - f_2 = m_2 a \qquad f_2 = m_3 a$$

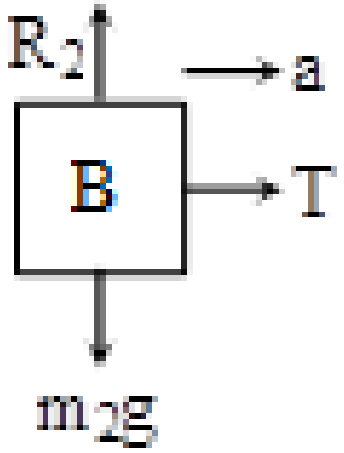
$$f_1 = \frac{(m_2 + m_3)F}{(m_1 + m_2 + m_3)}$$

$$f_2 = \frac{m_3 F}{(m_1 + m_2 + m_3)}$$

MOTION OF CONNECTED BODIES

a) For Two Bodies



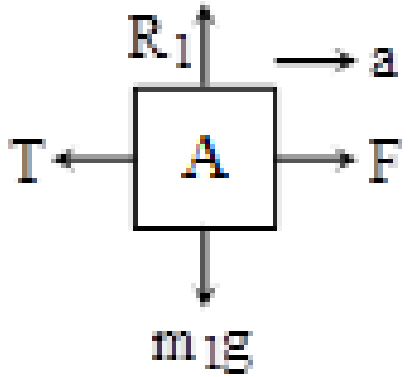


$$R_2 = m_2 g$$

$$T = m_2 a$$

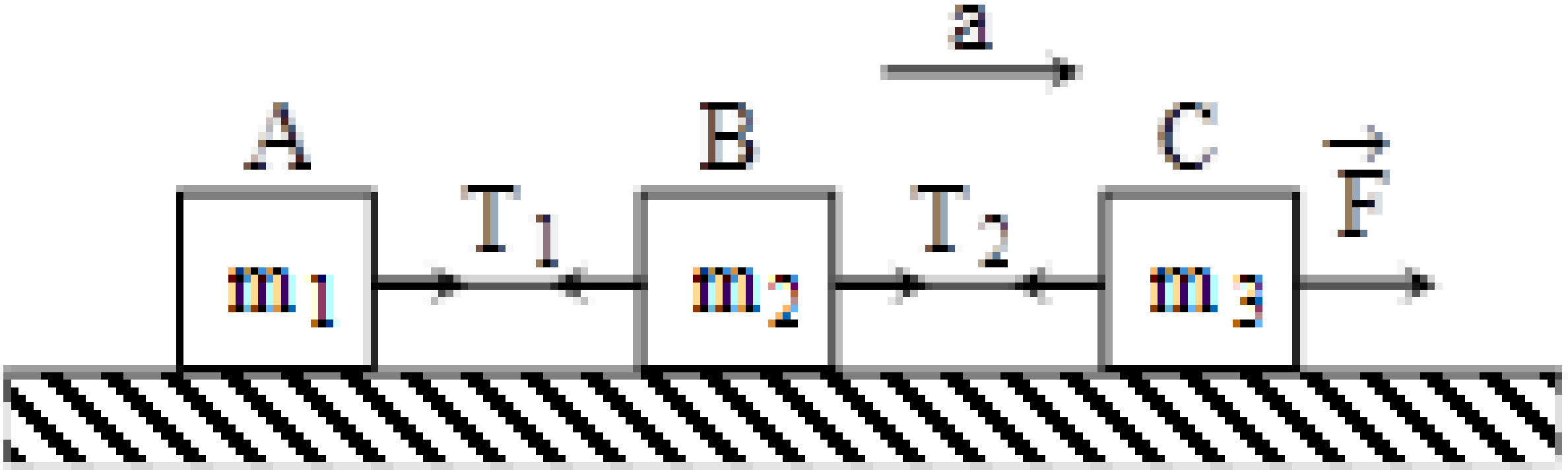
$$R_1 = m_1 g$$

$$F - T = m_1 a$$

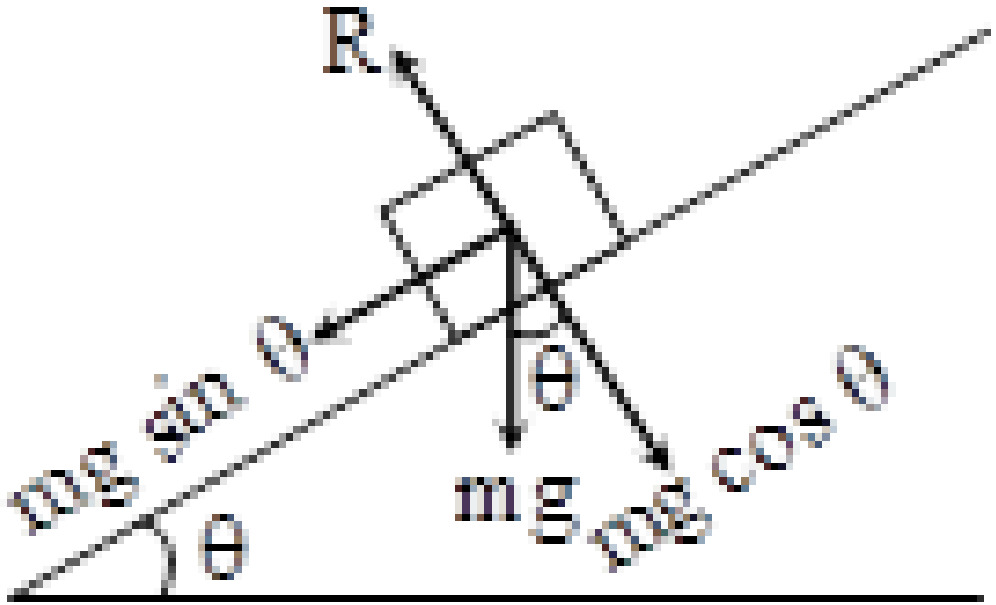


2) For Three bodies

$$F=(m_1+m_2+m_3)a$$



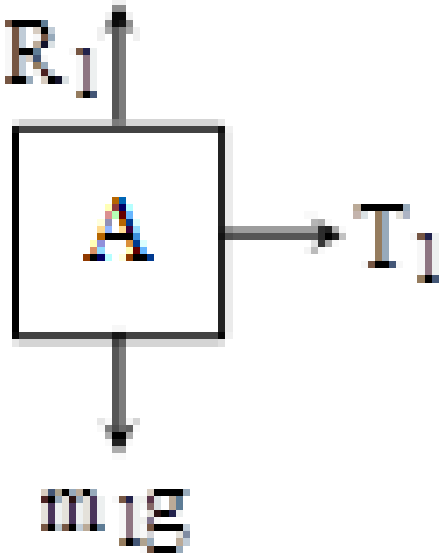
MOTION OF A BODY ON A SMOOTH INCLINED PLANE

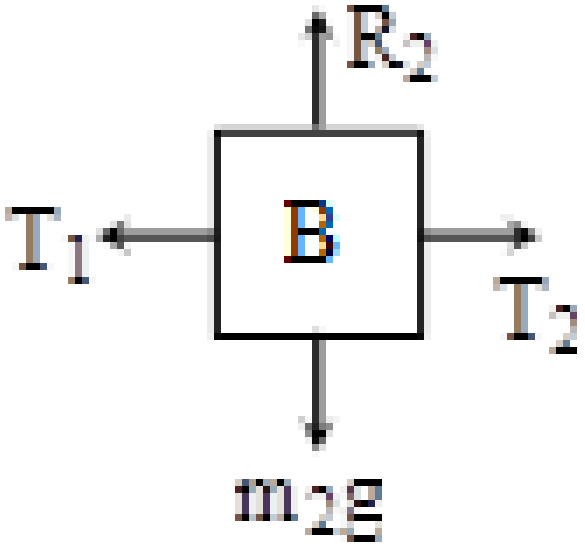


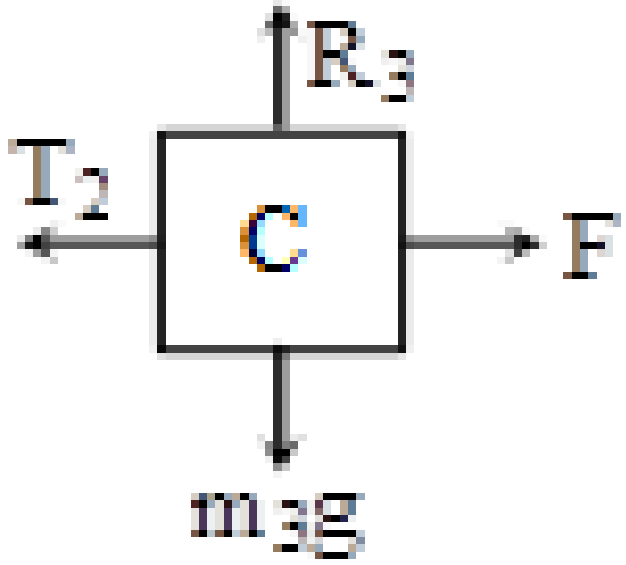
$$ma = mgSin\theta$$

$$Therefore,\ a = gSin\theta$$

$$R = mgCos\theta$$







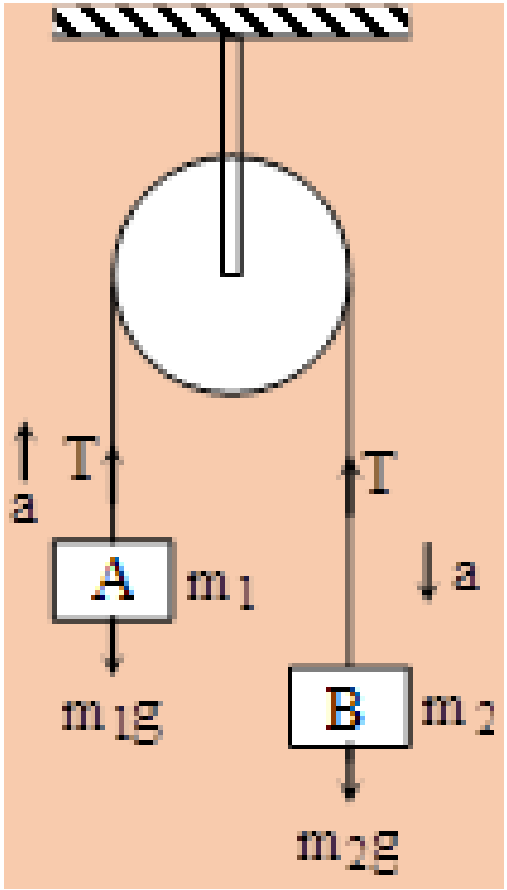
$$R_1 = m_1 g$$
$$T_1 = m_1 a$$

$$R_2 = m_2 g$$
$$T_2 - T_1 = m_2 a$$

$$R_3 = m_3 g$$
$$F - T_2 = m_3 a$$

MOTION OF TWO BODIES CONNECTED BY A STRING

a) Motion of unequal masses suspended from a light frictionless pulley:-



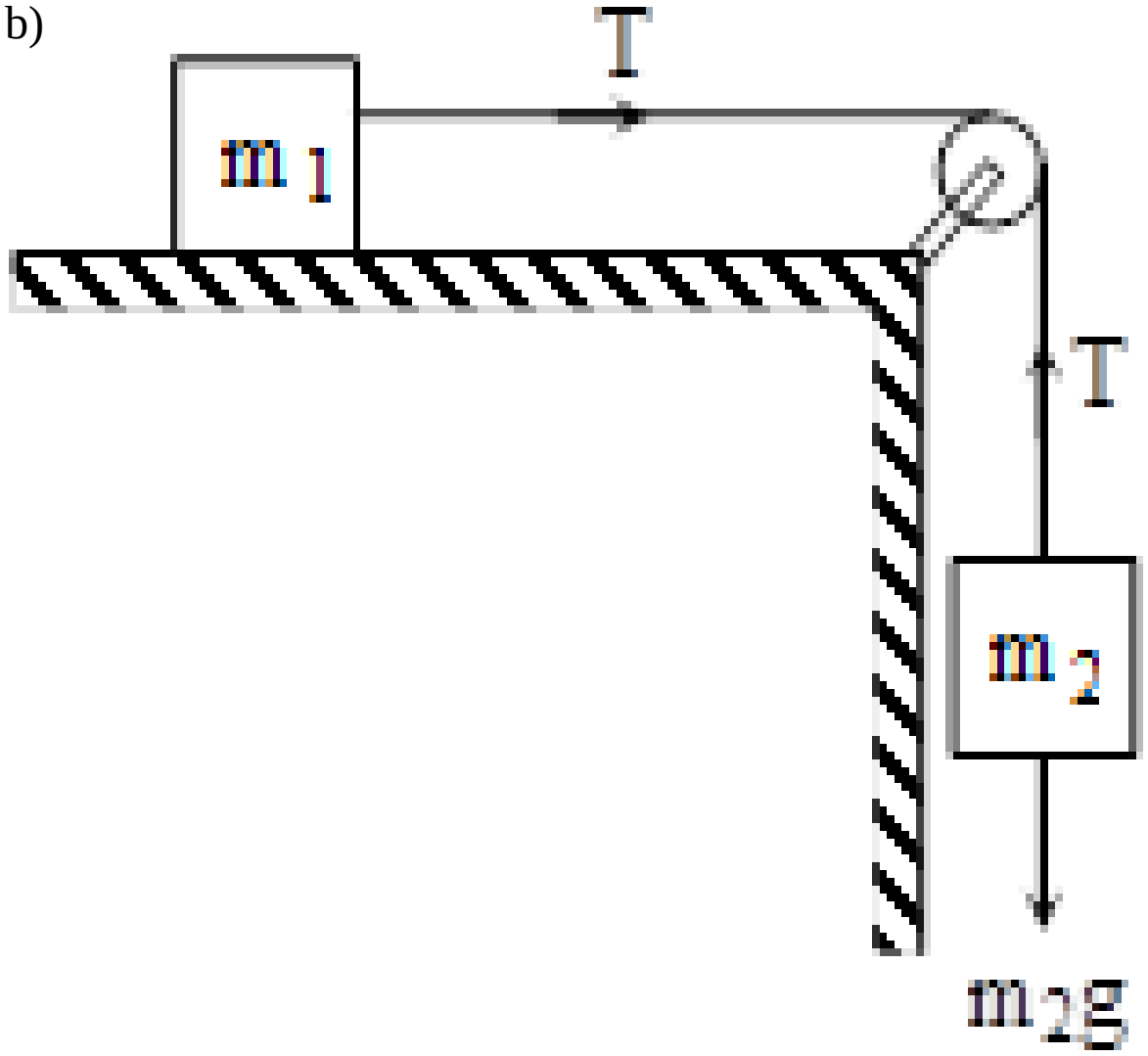
For the motion of A

$$T = m_1a + m_1g$$

For the motion of B

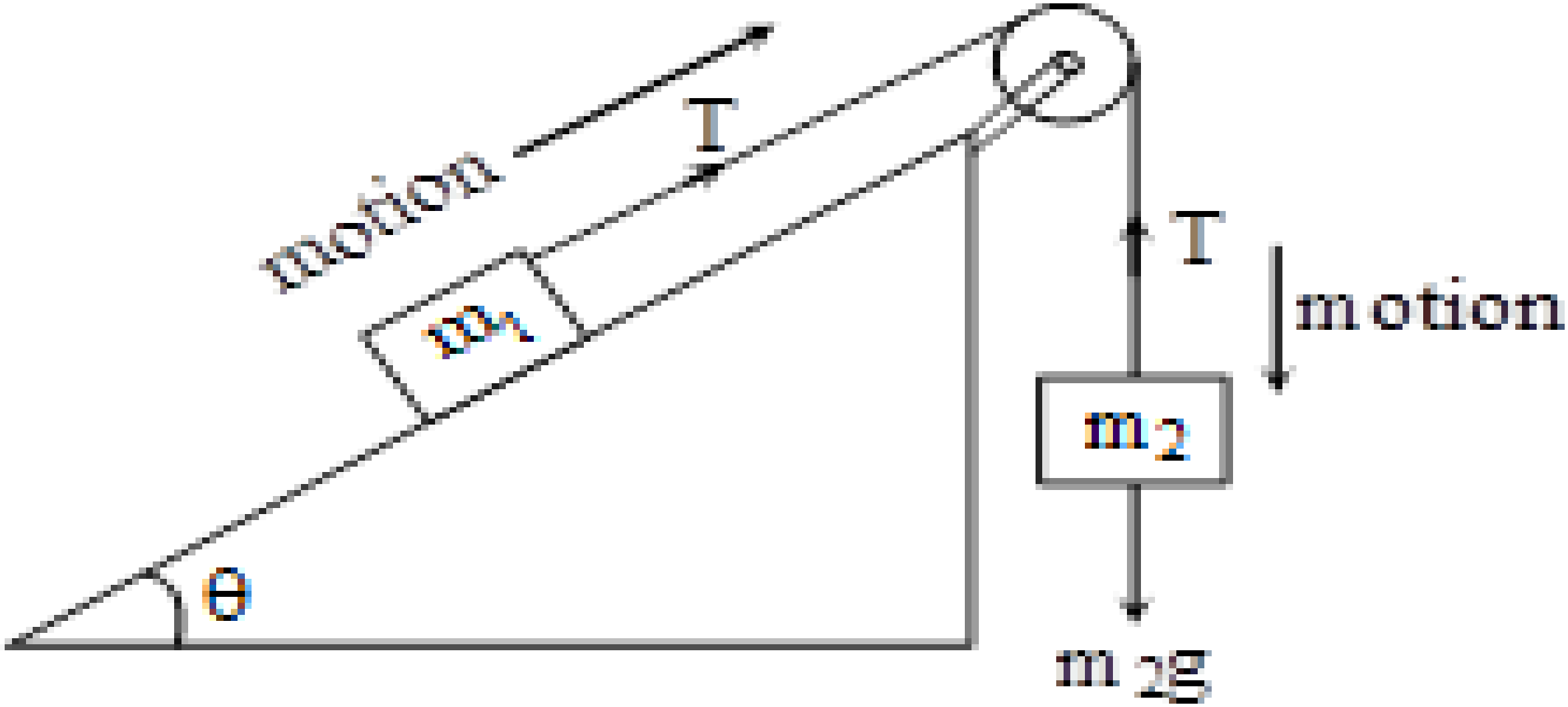
$$T = m_2g - m_2a$$

b)



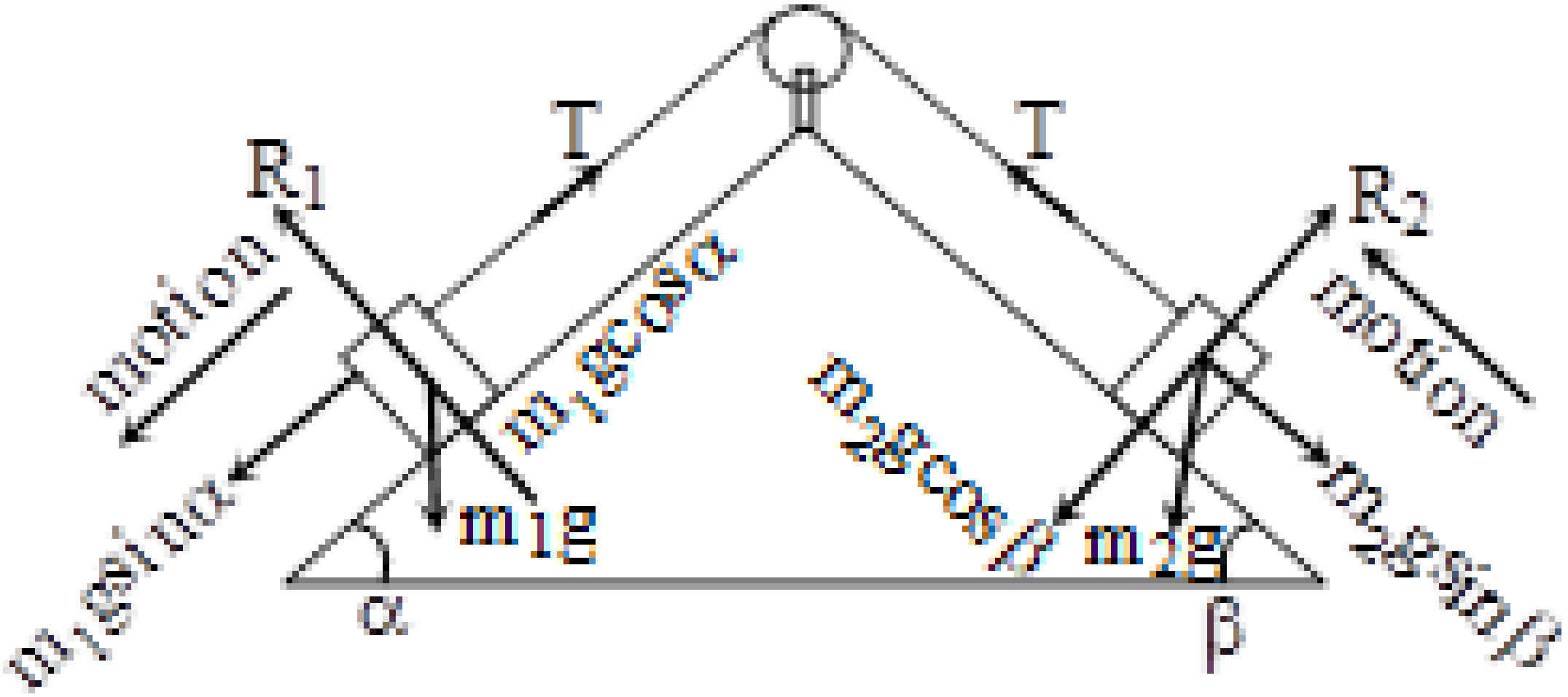
$$m_2 g - T = m_2 a$$

$$T = m_1 a$$



$$m_1 a = T - m_1 g Sin\theta$$

$$T = m_2 g - m_2 a$$



$$m_1 a = m_1 g Sin\alpha - T$$

$$m_2 a = T - m_2 g Sin\beta$$

FRICTION AND FRICTIONAL FORCE

If we slide or try to slide a body over a surface the motion is resisted by a bonding between the body and the surface. This resistance is represented by a single force and is called friction

अगर हम किसी सतह पर किसी बॉडी को स्लाइड या स्लाइड करने का प्रयास करते हैं तो गति का विरोध शरीर और सतह के बीच के संबंध से होता है। इस प्रतिरोध को एक बल द्वारा दर्शाया जाता है और इसे घर्षण कहा जाता है

a) Friction is a non conservative force, i.e. work done against friction is path dependent.

b) In its presence mechanical energy is not conserved. Thus friction reduces efficiency of a machine.

c) Normally with increase in smoothness friction decreases. But if the surface area are made too smooth by polishing and cleaning the bonding force of adhesion will increase and so the friction will increase resulting in 'Cold welding'

a) घर्षण एक गैर रूढ़िवादी शक्ति है, अर्थात घर्षण के विरुद्ध किया गया कार्य पथ पर निर्भर है।

बी) इसकी उपस्थिति में यांत्रिक ऊर्जा संरक्षित नहीं है। इस प्रकार घर्षण एक मशीन की दक्षता कम कर देता है।

c) सामान्य रूप से चिकनाई बढ़ने से घर्षण कम हो जाता है। लेकिन अगर सतह क्षेत्र को पॉलिश करके बहुत चिकना बनाया जाता है और आसंजन के बंधन बल में वृद्धि होगी और इसलिए घर्षण बढ़ेगा जिसके परिणामस्वरूप 'कोल्ड वेल्डिंग' होगा

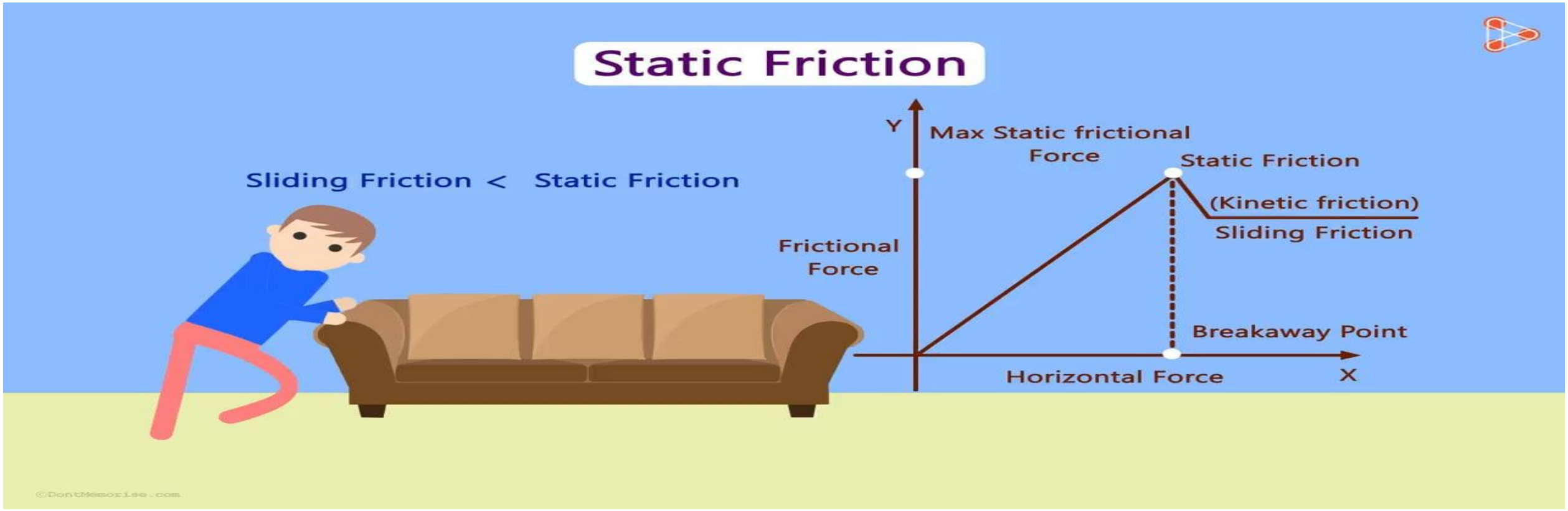
There are three types of frictional force

a) Static friction

b) Dynamic friction & Sliding friction

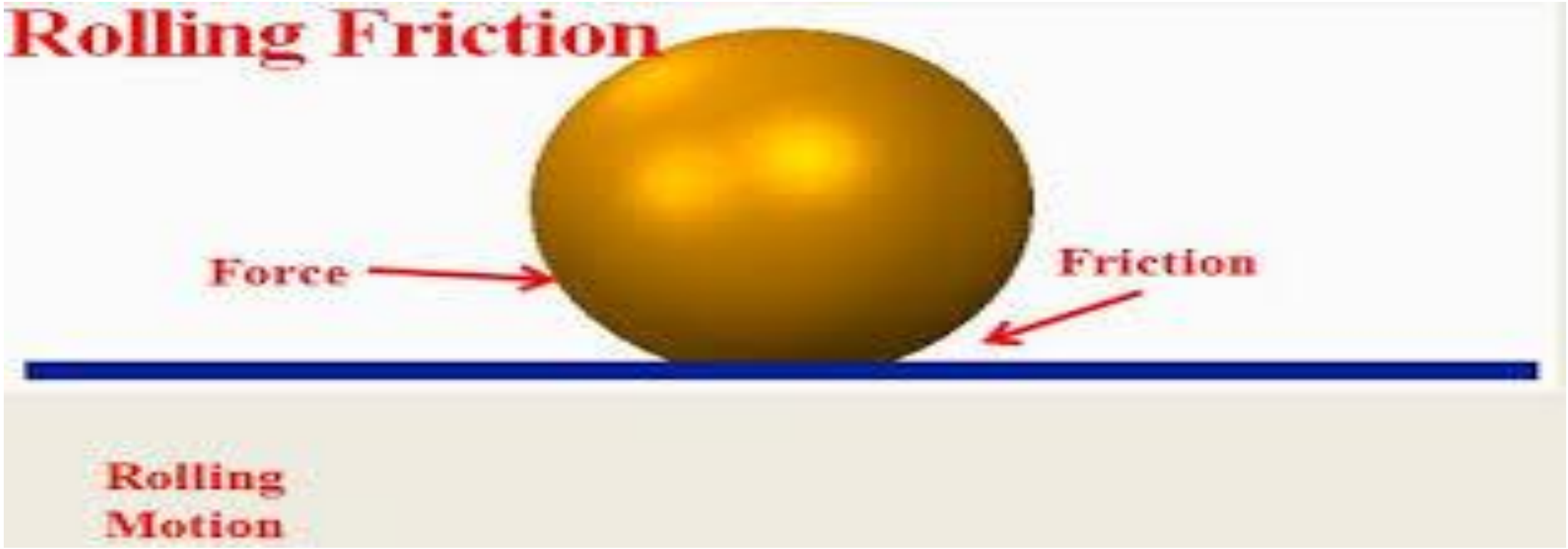
c) Rolling friction

a) The frictional force which is effective before motion starts between two planes in contact with each other, is known as static friction. Static friction is a self adjusting force with an upper limit, called limiting friction. The maximum force of static friction upto which body does not move is called limiting friction (fL)



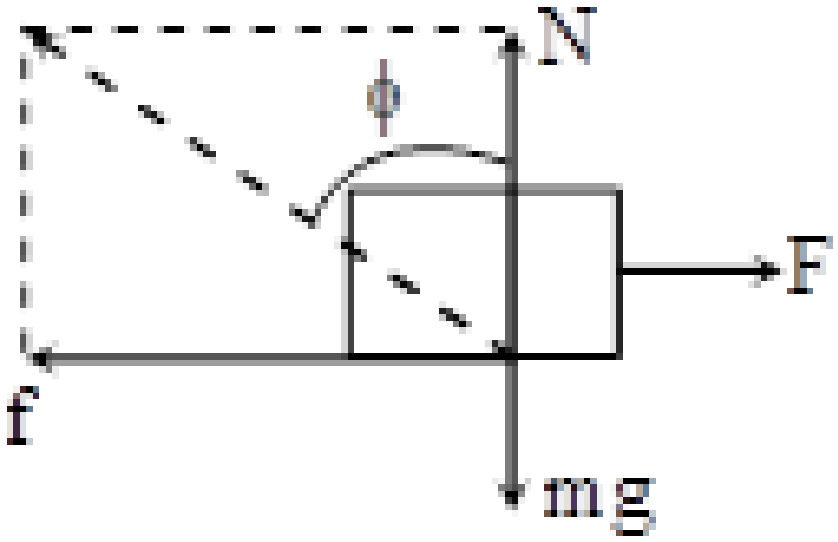
If the applied force is increased further and sets the body in motion, the friction opposing the motion is called dynamic or kinetic friction. Kinetic friction is lesser than limiting friction. we require more force to start a motion than to maintain it against friction

When a body (say wheel) rolls on a surface the resistance offered by the surface is called rolling friction. In rolling the surfaces at contact do not rub each other. The velocity of point of contact with respect to the surface remains zero all the time although the centre of the wheel moves forward.



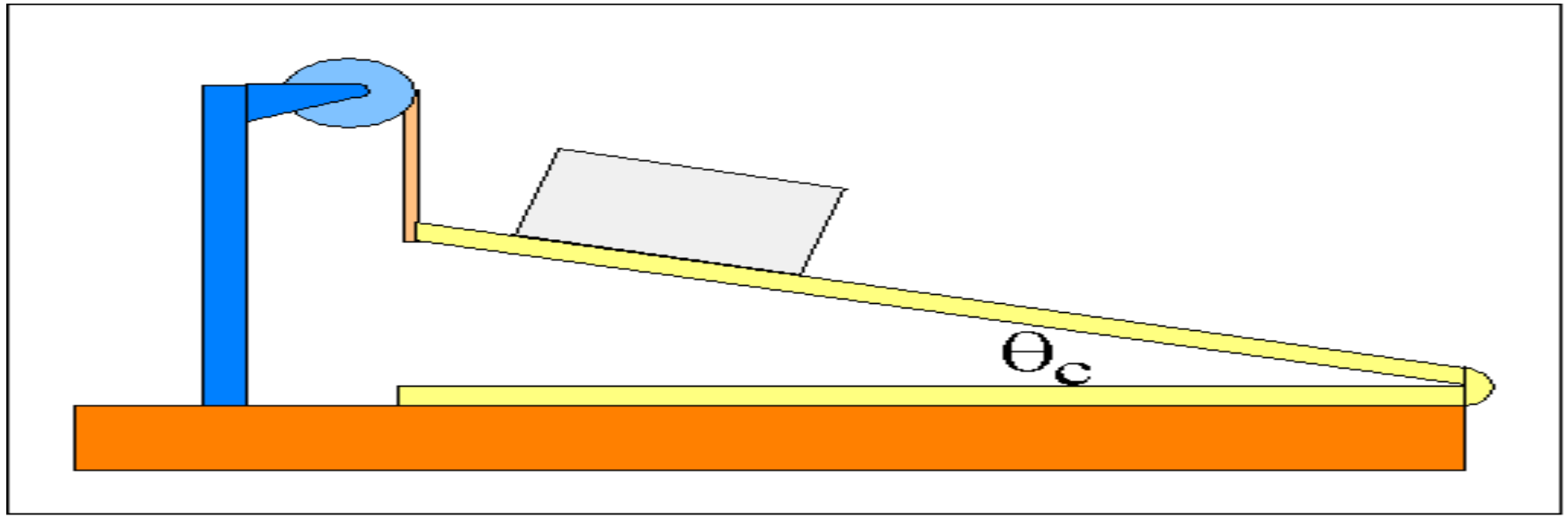
ANGLE OF FRICTION (ϕ)

$$tan\emptyset = \frac{f}{N} = \frac{\mu N}{N} = \mu$$



The angle of repose:-

minimum angle of inclination of the inclined plane at which a body placed at rest on the inclined plane is about to slide down in equilibrium condition.



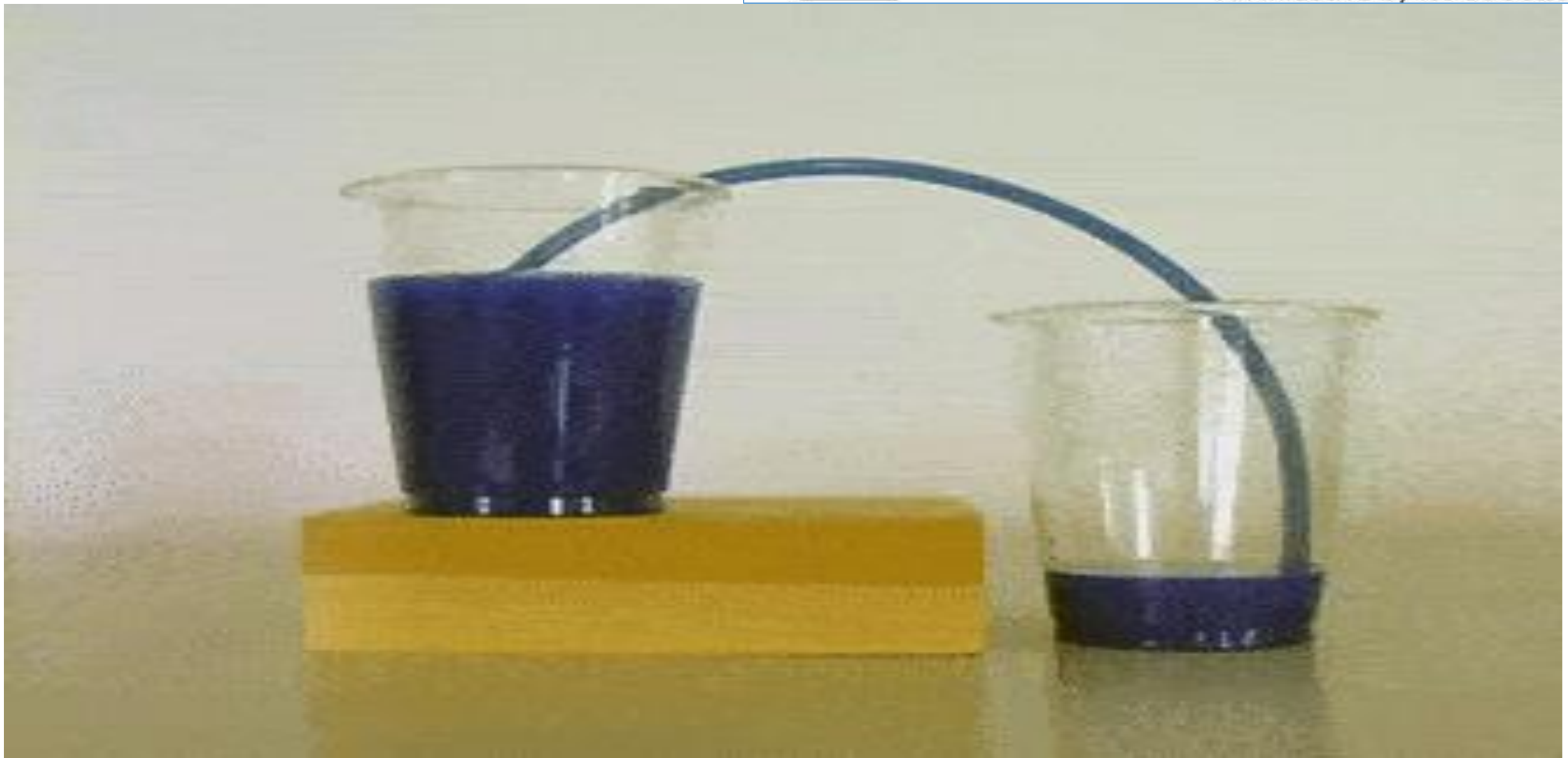
Rocket propulsion:-*The initial momentum of the rocket on its launching pad is zero. When it is fired from the launching pad, the exhaust gases rush downward at a high speed and to conserve momentum, the rocket moves upwards.*

(a) Thrust on the rocket:- $F = -u\frac{dm}{dt} - mg$

Siphon

A tube used to convey liquid upwards from a reservoir and then down to a lower level of its own accord. Once the liquid has been forced into the tube, typically by suction or immersion, flow continues unaided.

The Banu Musa brothers of 9th-century Baghdad invented



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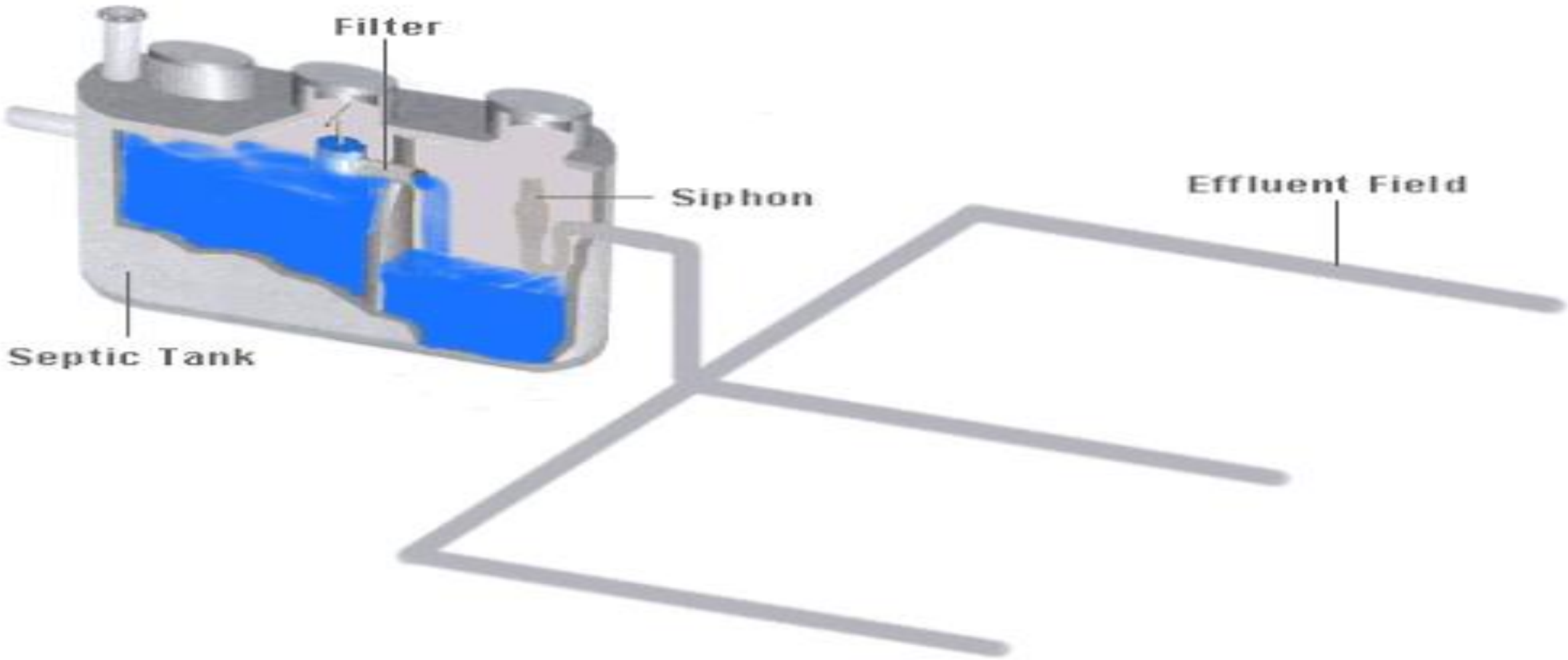
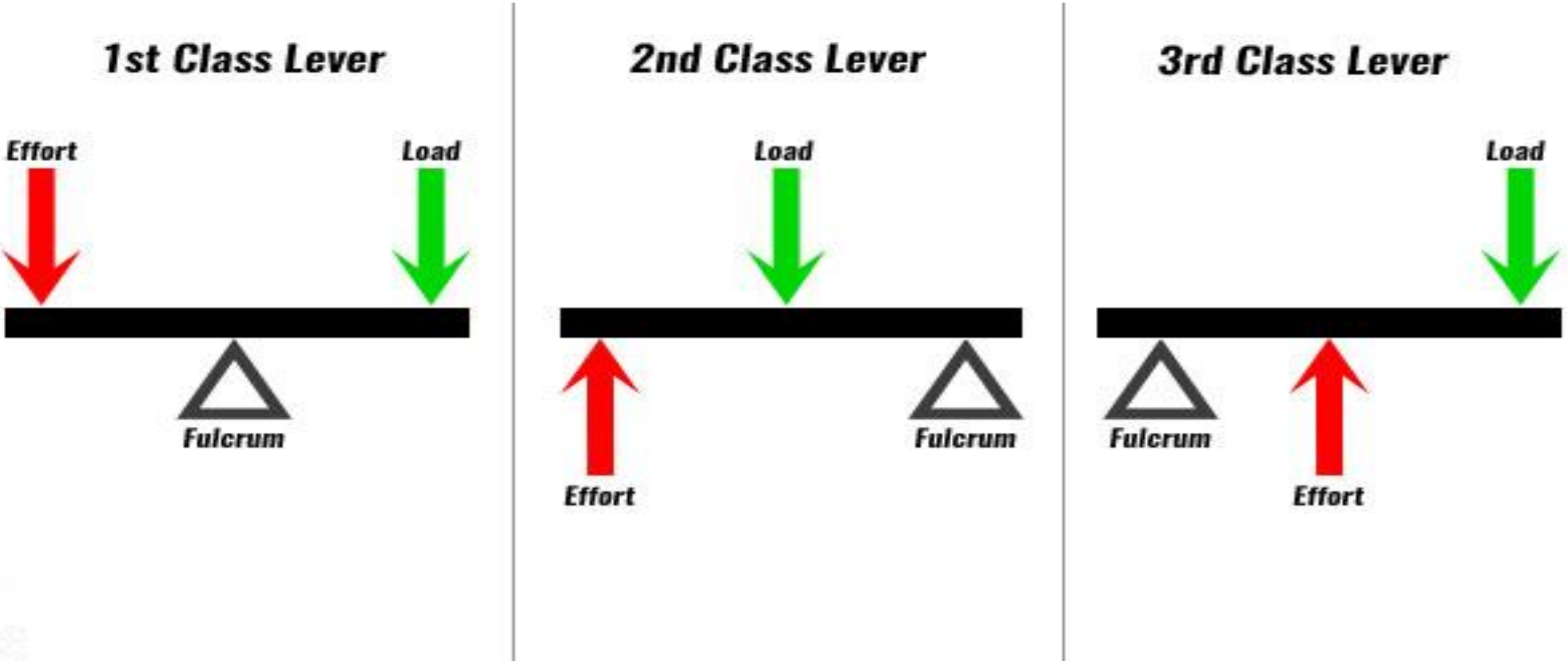


Levers is a simple machine consisting of a beam or rigid rod pivoted at a fixed hinge, or fulcrum. A lever is a rigid body capable of rotating on a point on itself. On the basis of the locations of fulcrum, load and effort, the lever is divided into three types.

a) first class

b) second class

c) third class



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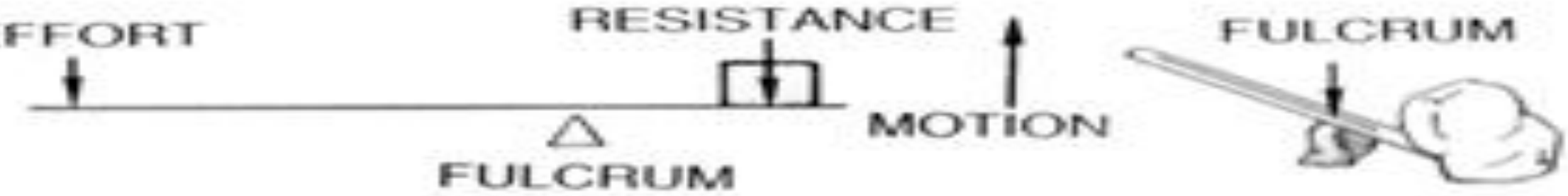


Simple machine: LEVER

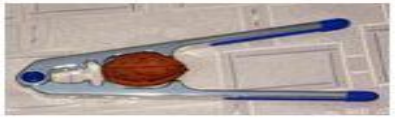
FIRST CLASS LEVER

PLIERS

SEE-SAW

SCISSORS

SECOND CLASS LEVER



NUTCRAKER

WHEELBARROW

BOTTLE OPENER

THIRD CLASS LEVER

TWEEZERS

SHEARING SCISSORS

TONGS

Hydrometer:-*an instrument for measuring the density of liquids. It was discovered by* **Nicholson in 1790.**