LECTURE 3

BOOK CHAPTER 4

(Projectile Motion)

Problem 23 (Book chapter 4):

A projectile is fired horizontally from a gun that is 45.0 m above flat ground, emerging from the gun with a speed of 250 m/s. (a) How long does the projectile remain in the air? (b) At what horizontal distance from the firing point does it strike the ground? (c) What is the magnitude of the vertical component of its velocity as it strikes the ground?

Answer: (a) We know

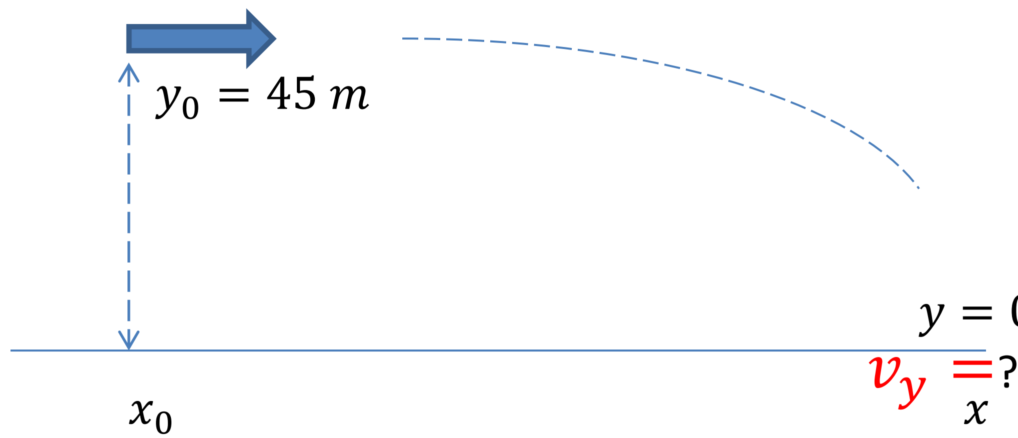
$$y - y_0 = (v_0 \sin\theta_0)\ t - \frac{1}{2} g t^2$$

$$0 - 45 = (v_0\ sin\ 0^0)\ t - 4.9t^2$$

$$-45 = 0 - 4.9t^2$$

$$\boxed{t = \sqrt{\frac{45}{4.9}} = 3.03\ s}$$

$v_0 = 250\ m/s$ and $\theta_0 = 0^0$, t = ?



(b) We know $x - x_0 = (v_0 \cos\theta_0)\ t$

$$x - x_0 = (250)(\cos 0^0)\ (3.03)$$

$$x - x_0 = (250)(1)(3.03)$$

$$\boxed{x - x_0 = 757.50\ m}$$

(c) We know $v_y = v_0 \sin\theta_0 - gt$ $\quad [v = u + at]$

$$v_y = 250(\sin 0^0) - (9.8)\,(3.03)$$

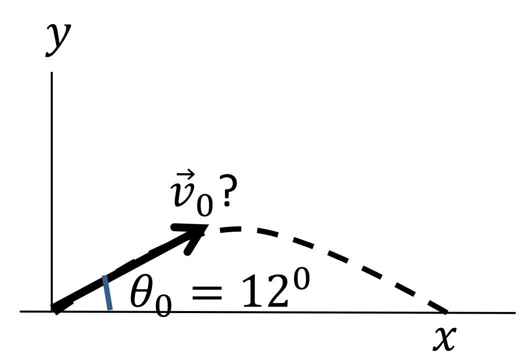
$$v_y = 0 - (9.8)\,(3.03)$$

$$v_y = -29.69 \text{ m/s}$$

The magnitude of v_y is 29.69 m/s

Problem 25 (Book chapter 4):

The current world-record motorcycle jump is 77.0 m, set by Jason Renie. Assume that he left the take-off ramp at 12.0º to the horizontal and that the take-off and landing heights are the same. Neglecting air drag, determine his take-off speed.



$R = x - x_0 = 77\ m$

Answer:

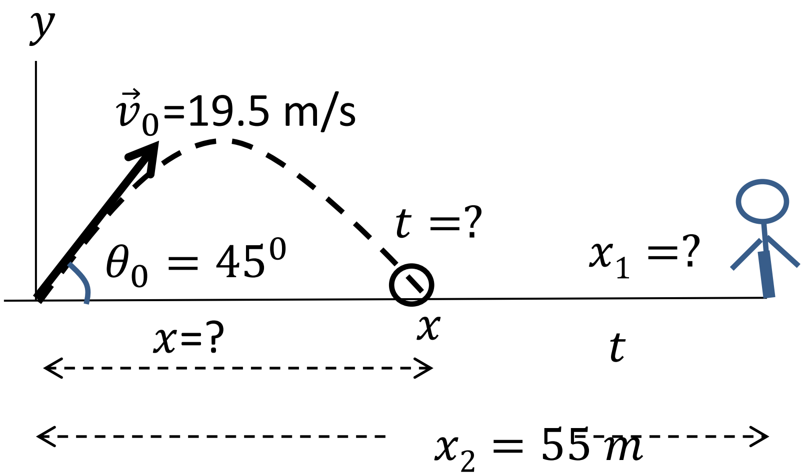
Since the take-off and landing heights are the same, that is $y - y_0 = 0$, we can use the formula

$$R = \frac{v_0^2 \sin 2\theta_0}{g} \qquad or \quad v_0 = \sqrt{\frac{Rg}{\sin 2\theta_0}}$$

$$or \ \ v_0 = \sqrt{\frac{(77)(9.8)}{\sin 24^0}} \qquad v_0 = \sqrt{\frac{754.6}{0.4067}} = 43.07\ m/s$$

Problem 30 (Book chapter 4):

A soccer ball is kicked from the ground with an initial speed of 19.5 m/s at an upward angle of 45°. A player 55 m away in the direction of the kick starts running to meet the ball at that instant. What must be his average speed if he is to meet the ball just before it hits the ground?



Answer: Here, $y - y_0 = 0$

We use the following formula to find the time of flight of the ball.

$$y - y_0 = (v_0 \sin\theta_0)\ t - \frac{1}{2} g t^2$$

$$0 = (19.5)\,(\sin\ 45^0)\ t - 4.9\ t^2$$

$$(19.5)(0.707)\ t = 4.9\ t^2$$

$$t = \frac{13.787}{4.9} = 2.81\ s$$

The player must take the time 2.81 s to meet the ball.

We need to find $x - x_0$ *to obtain the distance travled by the player.*

$$x - x_0 = (v_0 \cos\theta_0)\ t = (19.5)(\cos 45^0)(2.81)$$

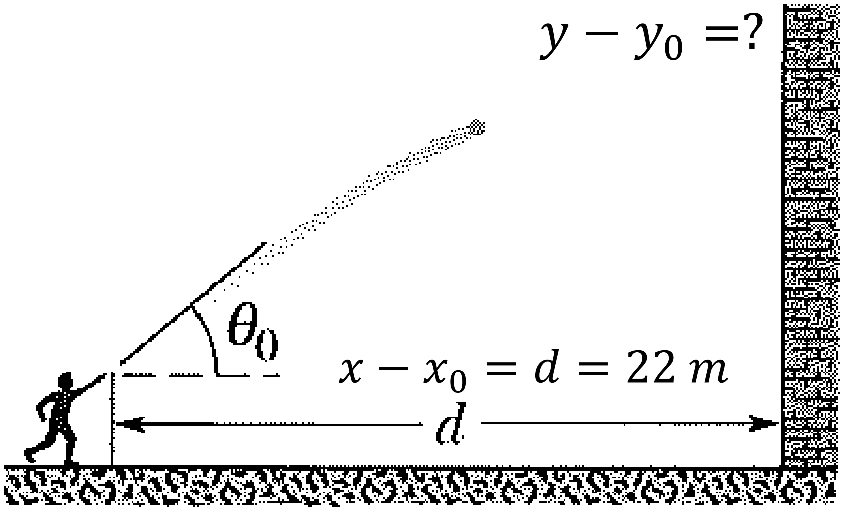
$$x - 0 = 38.74\ m$$

$$x = 38.74\ m$$

$$Average\ speed\ of\ the\ player = \frac{Distance\ traveled\ by\ the\ player, x1}{Time\ taken\ by\ the\ player, t} = \frac{55 - 38.74}{2.81} = 5.786\ \mathrm{m/s}$$

Problem 32 (Book chapter 4):

You throw a ball toward a wall at speed 25.0 m/s and at angle 40.0° above the horizontal (as shown in the figure). The wall is distance *d*= 22.0 m from the release point of the ball. (a) How far above the release point does the ball hit the wall? What are the (b) horizontal and (c) vertical components of its velocity as it hits the wall? (d) When it hits, has it passed the highest point on its trajectory?



$v_0 = 25\ m/s\ ;\ \ \theta_0 = 40^0$

$t = ?$

$(a)\ y - y_0 = ?\ \ (b)\ v_x = ?\ \ \ and\ (c)\ v_y = ?$

$(d)\ Did\ the\ ball\ pass\ the\ highest\ point?$

Answer:

(a) $y - y_0 = (v_0 \sin\theta_0)\ t - \frac{1}{2} g t^2$

$$y - y_0 = (25)(\sin\ 40^0)\ t - 4.9\ t^2$$

$$y - y_0 = (25)(0.6428)t - 4.9\ t^2$$

$$y - y_0 = 16.07t - 4.9\ t^2$$

To find t we use the following formula,

$$x - x_0 = (v_0 \cos\theta_0)\ t$$

$$t = \frac{x - x_0}{v_0 \cos\theta_0} = \frac{22}{25\ cos40^0} = \frac{22}{(25)(0.7660)}$$

$$t = 1.149\ s$$

Therefore,

$$y - y_0 = (16.07)(1.149) - (4.9)(1.149)^2 = 18.46 - 6.469 = 11.99\ m$$

(b) We know $v_x = v_{0x} = v_0 \cos\theta_0 = 25\cos 40^0 = (25)(0.766) = 19.15\, m/s$

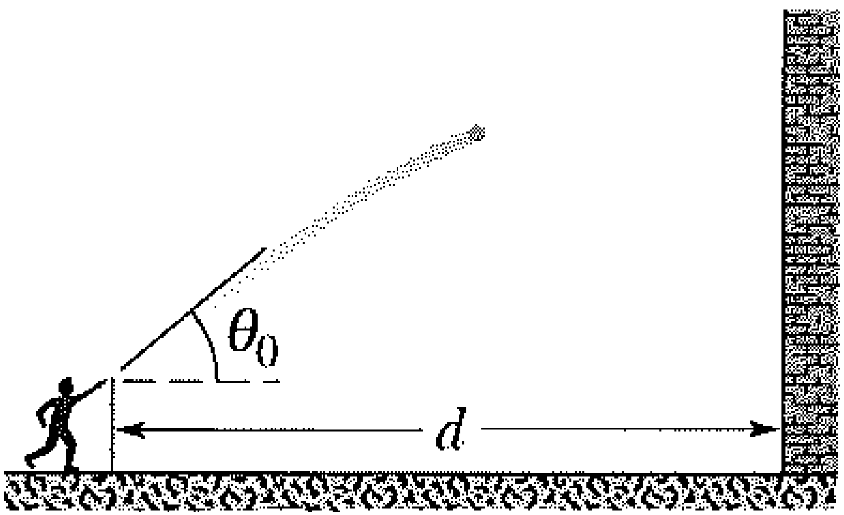
(c) We know $v_y = v_0 \sin\theta_0 - gt = 25\sin 40^0 - (9.8)(1.149)$ [v = u +at]

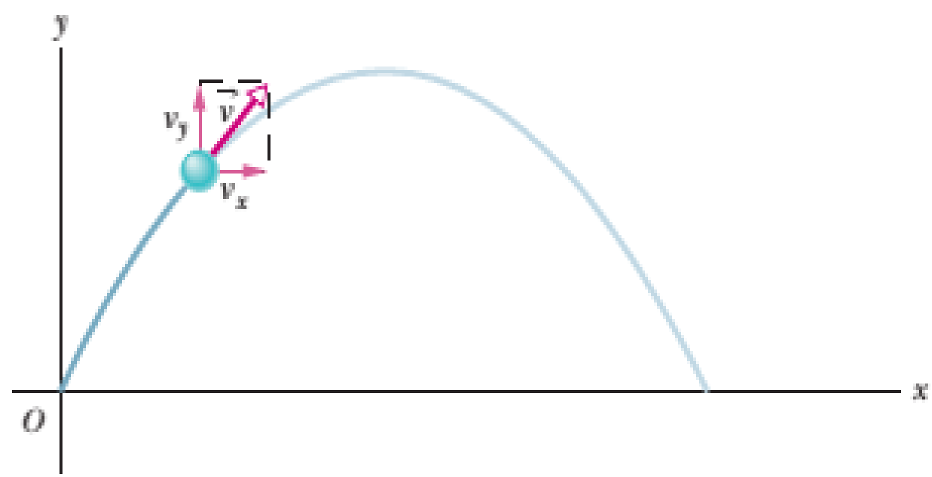
$$v_y = (25)(0.6428) - 11.26 = 4.81 \text{ m/s}$$

(d) Since v_y *is positive, that is,* $v_y > 0$, *the ball did not reach to the highest point on hitting the wall.*

$v_y = ?$

$v_x = ?$





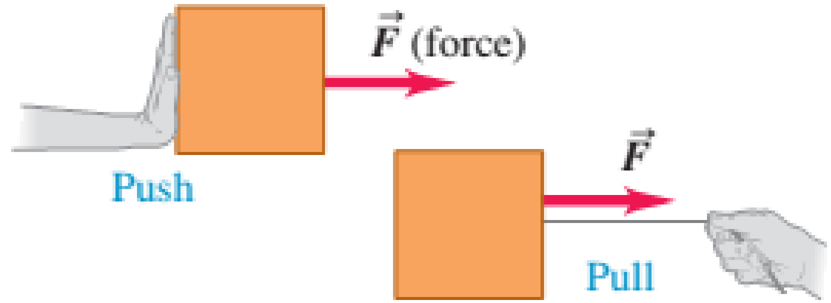
LECTURE 4

BOOK CHAPTER 5

(Force and Motion-I)

Force:

- A force is a push or a pull.
- A force is an interaction between two obj
- A force is a vector quantity, with magnitu

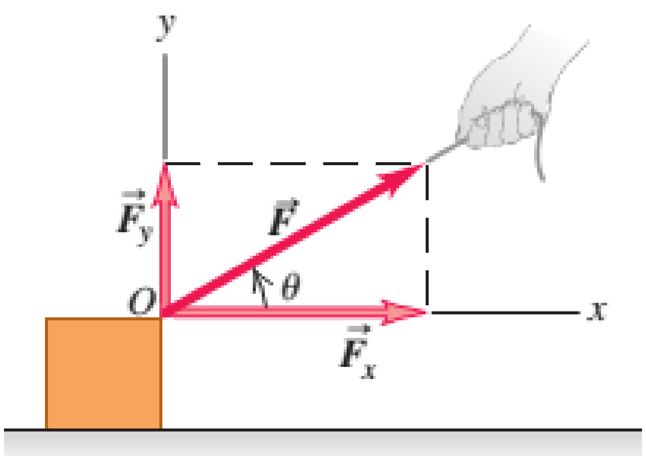


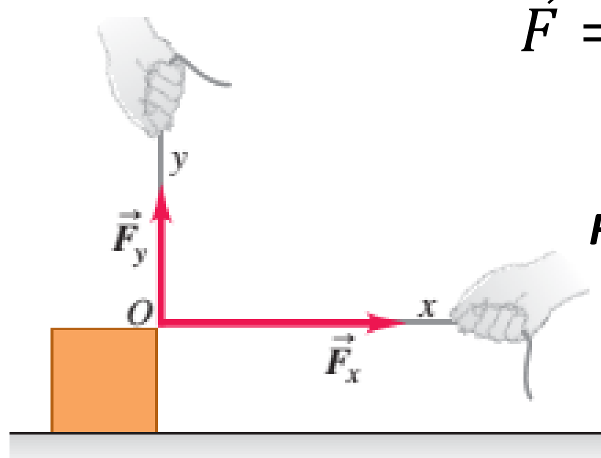
Unit of force:
SI unit: Newton (N); CGS unit: dyne; British unit: poundal(pdl)=pound-force(lbf)

MKS: F = ma=kg-m/s2=N; CGS: F = ma=gm-cm/s2=dyne;
FPS: F = ma=lb-ft/s2= poundal(pdl); pound=unit of mass=lb; 1 slug=32 lb

If two or more forces act on a body, we find the **net force** (or **resultant force**) by adding them as vectors.

$$\vec{F} = F_x\hat{\imath} + F_y\hat{\jmath}$$





Reference: university Physics

The force , which acts at an angle from the *x*-axis, may be replaced by its rectangular component vectors $\vec{F}_x$ and $\vec{F}_y$. $Here\ F_x = F cos\theta\ \ and\ \ F_y = F sin\theta$.

Some Particular Forces:

The Gravitational Force:

A **gravitational force** on a body is a pull by another body. In most situations, the other body is Earth or some other astronomical body. For Earth, the force is directed down toward the ground, which is assumed to be an inertial frame.

With that assumption, the magnitude of $\vec{F}_g$ is

$$F_g = mg$$

where m is the body's mass and g is the magnitude of the free-fall acceleration.

Normal Force:

A **normal force** $\vec{\boldsymbol{F}}_N$ is the force on a body from a surface against which the body presses. The normal force is always perpendicular to the surface.

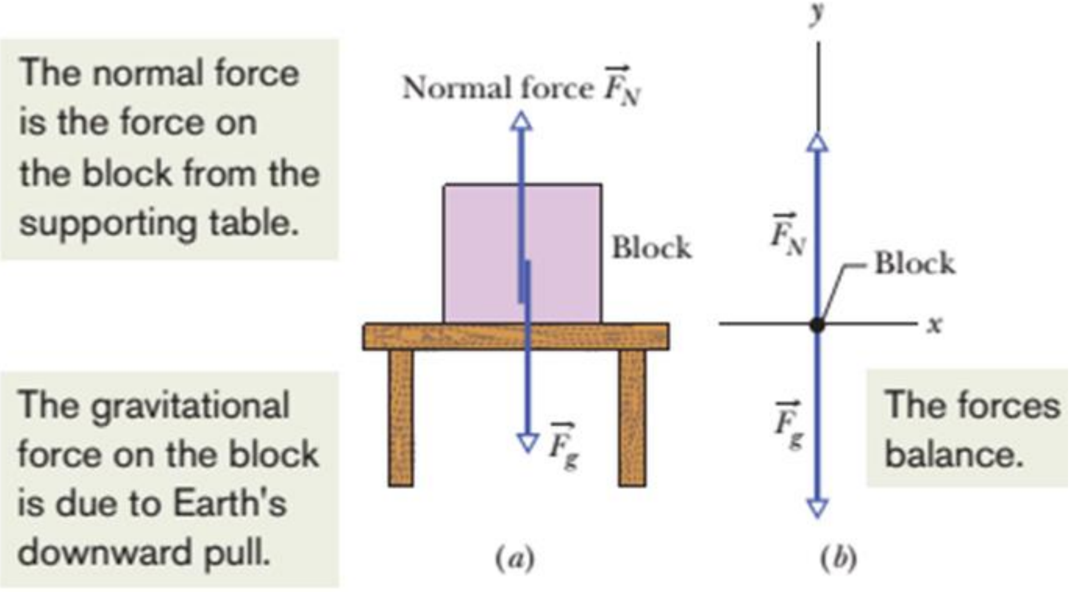


Figure (*a*) A block resting on a table experiences a normal force perpendicular to the tabletop. (*b*) The free-body diagram for the block.

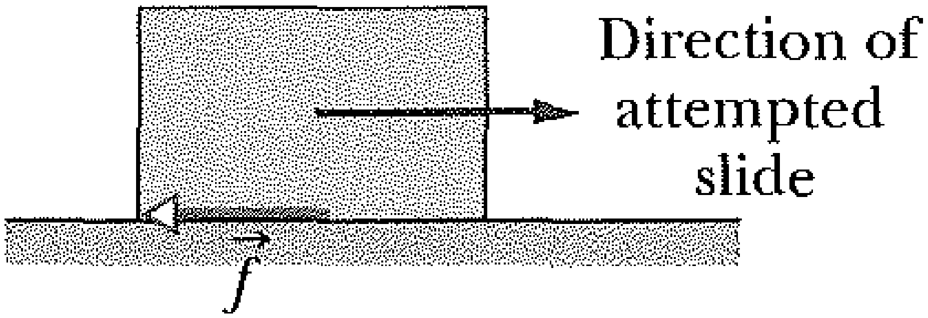
Weight:

The weight W of a body is equal to the magnitude F_g of the gravitational force on the body.

That is, $W = F_g = mg$

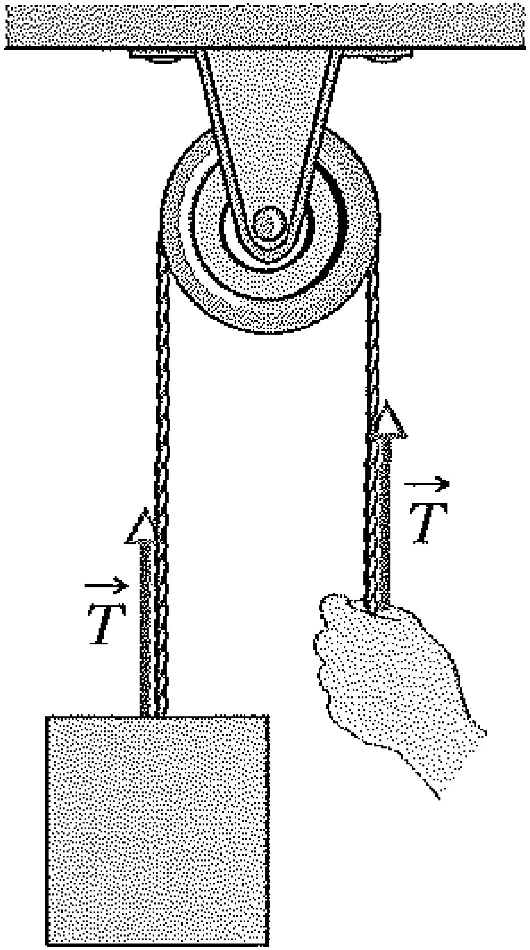
Frictional force:

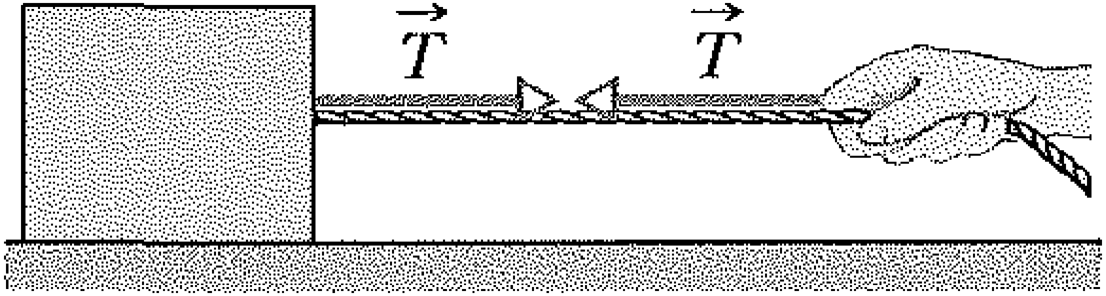
A **frictional force** is the force on a body when the body slides or attempts to slide along a surface. The force is always parallel to the surface and directed so as to oppose the sliding. On a *frictionless surface,* the frictional force is negligible.



Tension:

When a cord (or a rope, cable, or other such object) is attached to a body and pulled taut, the cord pulls on the body with a force directed away from the point of attachment to the body and along the cord (as shown in the adjacent figure). The force is often called a *tension force.* For a *massless* cord (a cord with negligible mass), the pulls at both ends of the cord have the same magnitude *T*, even if the cord runs around a *massless, frictionless pulley* (a pulley with negligible mass and negligible friction on its axle to oppose its rotation).





Newtonian Mechanics:

The relation between a force and the acceleration it causes was first understood by Isaac Newton (1642 –1727) .The study of that relation, as Newton presented it, is called *Newtonian mechanics.* We shall focus on its three primary laws of motion.

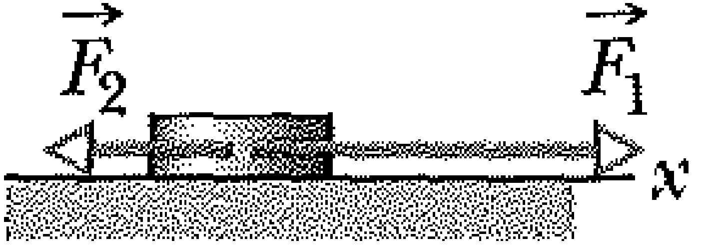
Newton's First Law:

If there is no net force on a body, the body remains at rest if it is initially at rest or moves in a straight line at constant speed if it is in motion.

OR

If no *net* force acts on a body ($\vec{F}_{net} = 0$), the body's velocity cannot change; that is, the body cannot accelerate.

Newton's Second Law:



The net force($\vec{F}_{net}$) on a body is equal to the product of the body's mass (m) and its acceleration ($\vec{a}$).

In vector equation form,

$$\vec{F}_{net} = m\vec{a}$$

For a specific case along x-axis,

$$F_{net,x} = ma_x$$

$$F_1 - F_2 = ma_x$$

Units in Newton's Second Law

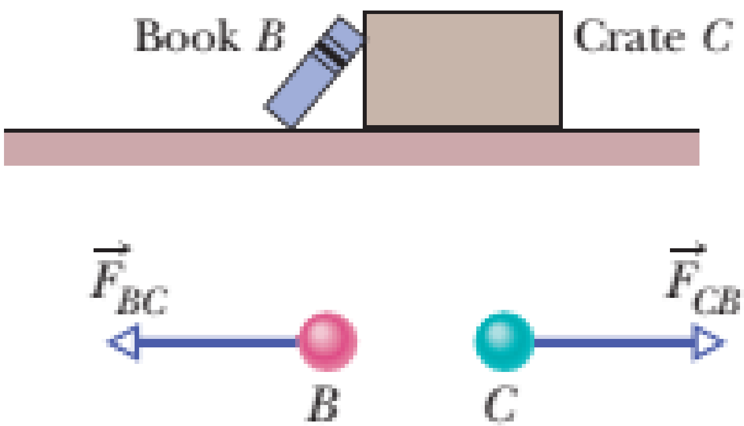
System	Force	Mass	Acceleration
SI	newton (N)	kilogram (kg)	m/s^2
CGS[a]	dyne	gram (g)	cm/s^2
British[b]	pound (lb)	slug	ft/s^2

[a] 1 dyne = 1 $g \cdot cm/s^2$.

[b] 1 lb = 1 $slug \cdot ft/s^2$.

Newton's Third Law:

When two bodies interact, the forces on the bodies from each other are always equal in magnitude and opposite in direction.



For the book and crate, we can write this law as the vector relation

$$\vec{F}_{BC} = -\vec{F}_{CB}$$

(equal magnitudes and opposite directions)

The force on B due to C has the same magnitude as the force on C due to B.

Free-body diagram for an object:

A **free-body diagram** is a stripped-down diagram in which only *one* body is considered. That body is represented by either a sketch or a dot. The external forces on the body are drawn (as shown in figure 2), and a coordinate system is superimposed, oriented so as to simplify the solution.

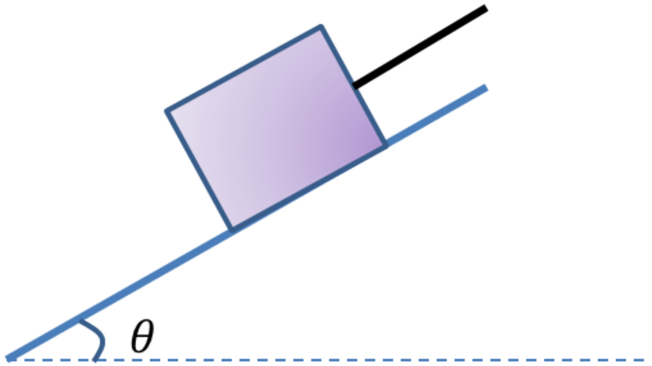


Fig.1 A box is pulled up a plane by a cord.

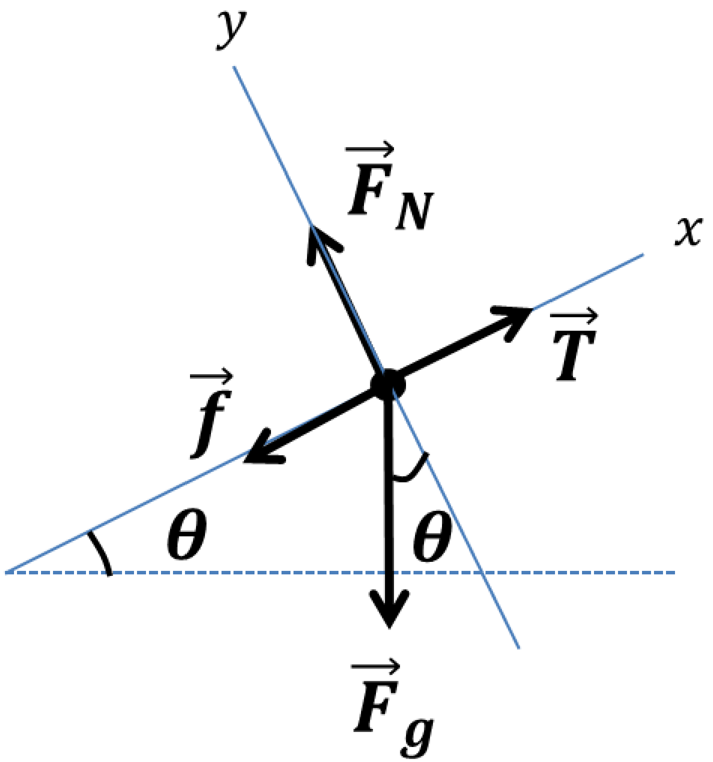
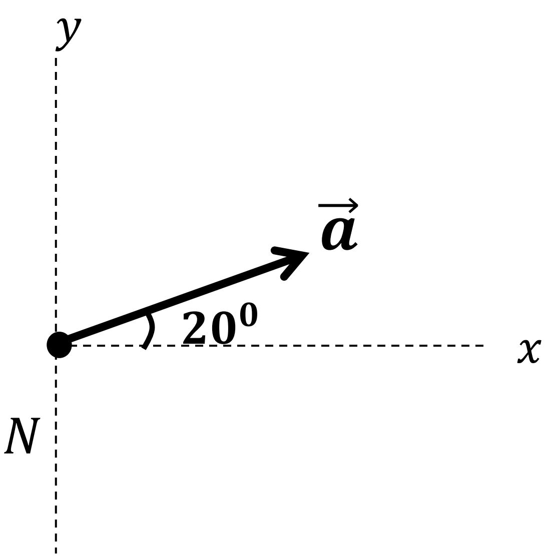


Fig.2 Four forces acting on the box:
The tension force ($\vec{T}$), the normal force($\vec{F}_N$), the frictional force($\vec{f}$), and the gravitational force($\vec{F}_g$).

Problem 3 (Book chapter 5):

If the 1 kg standard body has an acceleration of 2.00 m/s^2 at 20.0° to the positive direction of an *x* axis, what are (a) the *x* component and (b) the *y* component of the net force acting on the body, and (c) what is the net force in unit-vector notation?



Answer:

(a) The x component acceleration, $a_x = a\cos 20^0$

$$a_x = (2)(0.9397) = 1.879\ m/s^2$$

The x component force, $F_x = ma_x = (1)(1.879) = 1.879\ N$

(b) The y component acceleration, $a_y = a\sin 20^0$

$$a_y = (2)(0.3420) = 0.6840\ m/s^2$$

The y component force, $F_y = ma_y = (1)(0.6840) = 0.6840\ N$

(c) The resultant force (net force) in unit -vector notation,

$$\vec{F} = F_x\hat{\imath} + F_y\hat{\jmath} = 1.879\ \hat{\imath} + 0.684\ \hat{\jmath}$$

Thank You