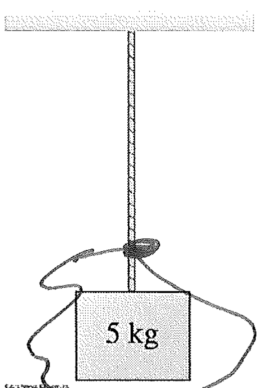
Chapter 4, Sections 4.2-4.7

4.2 - Force

(1.) For the following situations:

- Identify the forces acting on the object.
- Draw a free-body diagram for the object.
- Find the magnitude of the requested force by applying Newton's First Law of Motion.

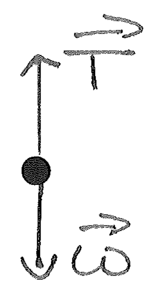
(a) A 5.0 kg mass is hung from the ceiling using a thin rope. Find the tension force exerted by the rope on the 5 kg mass. *Hint:* A 5 kg mass has a weight of 49 N on earth where this problem is taking place.



Forces: Only Contact Force is upwards Tension $\vec{T}$

Long-Range = $\vec{W}$ DOWN

Free-Body Diagram:

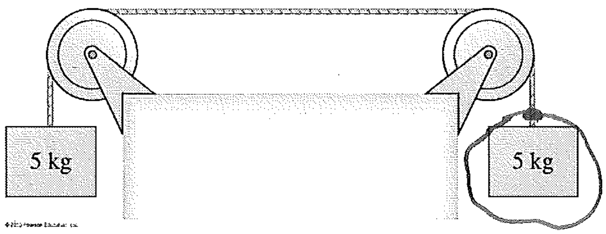


Tension Calculation:

Not Moving ⇒ $\sum \vec{F} = 0$

⇒ $\vec{T} + \vec{W} = 0$ ⇒ $\vec{T} = -\vec{W}$ ⇒ $T = W$ in magnitude ⇒ $T = 49N$, $\vec{T} = 49N$, up

(b) Two 5 kg masses are connected to each over pulleys using a rope. What is the tension force that the rope exerts on the right-hand mass if they are both at rest?

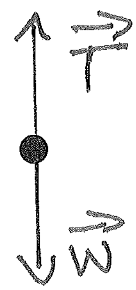


Forces:

ON RIGHT MASS ONLY CONTACT FORCE IS TENSION, $\vec{T}$ UP

LONG-RANGE, $\vec{W}$ DOWN. 5kg $\Rightarrow W = 49N$

Free-Body Diagram:



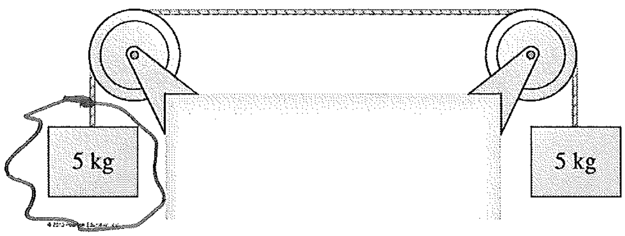
Tension Calculation:

NOT MOVING

$\Rightarrow \sum \vec{F} = 0$

$\Rightarrow \vec{T} + \vec{W} = 0 \Rightarrow \vec{T} = -\vec{W} \Rightarrow \underline{\vec{T} = 49N, \text{ up}}$

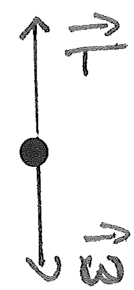
(c) Two 5 kg masses are connected to each over pulleys using a rope. What is the tension force that the rope exerts on the left-hand mass if they are both at rest?



Forces: ON LEFT MASS, ONLY CONTACT FORCE IS TENSION $\vec{T}$ UP

ONLY LONG-RANGE: $\vec{\omega}$ = 49N DOWN SINCE ANOTHER 5KG

Free-Body Diagram:



Tension Calculation:

LEFT MASS NOT MOVING EITHER $\Rightarrow \sum \vec{F} = 0$

$$\Rightarrow \vec{T} + \vec{\omega} = 0 \Rightarrow \vec{T} = -\vec{\omega} \Rightarrow \vec{T} = 49N, \text{up}$$

NOTICE HOW THE TENSION ON BOTH ENDS OF THE ROPE WAS THE SAME. This IS ALWAYS TRUE FOR "MASSLESS" ROPES.

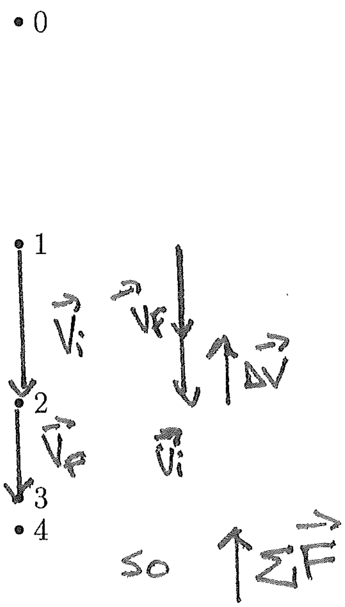
Negligible MASS

4.6 - Newton's Second Law

(1.) For the following motion diagrams, draw and label the net force vector at point 2. Also, write a one or two sentence "story" about a real object that would have the motion diagram and net force.

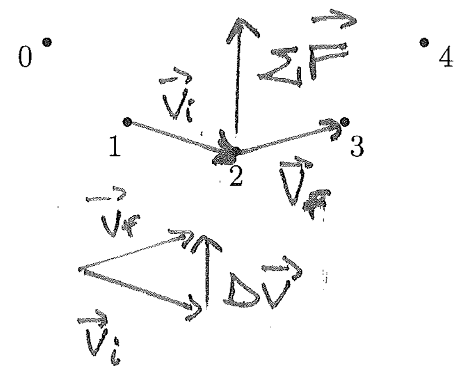
(*a*)

NET FORCE IN SAME DIRECTION AS ACCELERATION ⇒ SAME DIRECTION AS $\Delta\vec{v} = \vec{v}_f - \vec{v}_i$



A PARACHUTIST OPENS HER CHUTE AND SLOWS DOWN. SHE HAS AN UPWARD NET FORCE AND ACCELERATION.

(*b*)



A BICYCLE RIDING DOG GOING AROUND A CIRCLE WITH CONSTANT SPEED HAS AN UPWARDS NET FORCE & ACCELERATION AT THE "BOTTOM" OF THE CIRCLE.

(2.) A constant net force applied to an object makes it accelerate at $10\,m/s^2$.
What will the acceleration be if:

(a) The net force is doubled? $20\,m/s^2$ $a = \frac{\Sigma F}{M} \Rightarrow \frac{2\Sigma F}{M} = 2a$

(b) The mass is doubled? $5\,m/s^2$ $a = \frac{\Sigma F}{M} \Rightarrow \frac{\Sigma F}{2M} = \frac{a}{2}$

(c) The net force *and* mass are doubled? $10\,m/s^2$ $\frac{2\Sigma F}{2M} = \frac{\Sigma F}{M} = a$

(d) The net force is doubled and the mass is halved? $40\,m/s^2$ $\frac{2\Sigma F}{\frac{1}{2}M} = 4\left(\frac{\Sigma F}{M}\right) = 4a$

(3.) What is the weight of a $10\,kg$ object on earth and on the moon? *Hint:* The acceleration due to gravity on the moon is roughly 1/3 that of earth.

ON EARTH, $W = Mg \Rightarrow W = (10\,kg)(9.8\,m/s^2) = 98\,N$

ON MOON $g = \frac{1}{3}(9.8\,m/s^2) = 3.266..\,m/s^2 \Rightarrow W = (10\,kg)(3.266..\,m/s^2)$

$= 32.666..\,m/s^2$

$= 33\,N$

(4.) What is the mass of a $10\,kg$ object on earth and on the moon?

MASS DOES NOT CHANGE SINCE AMOUNT OF MATTER THE SAME

$\Rightarrow M = 10\,kg$ ON BOTH

(5.) What is the mass in kilograms of a 125 N object if that weight was measured on the earth or on the moon?

$W = Mg \Rightarrow M = \frac{W}{g}$ $\Rightarrow$ ON EARTH, $M = \frac{125N}{9.8 m/s^2} = 12.7551 Kg$

$= ~~12 Kg~~$ 12.8 Kg

ON MOON: $M = \frac{125N}{3.266 m/s^2} = 38.3 Kg$

(6.) What is the weight of a 12.5 g object on earth?

$W = Mg$ but $1N = 1 Kg \cdot m/s^2 \Rightarrow$ Have to use Kg

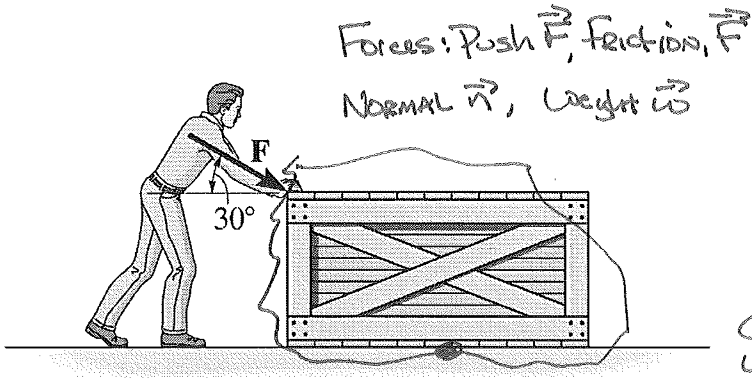
$M = 12.5g \times \frac{Kg}{1000g} = 0.0125 Kg$

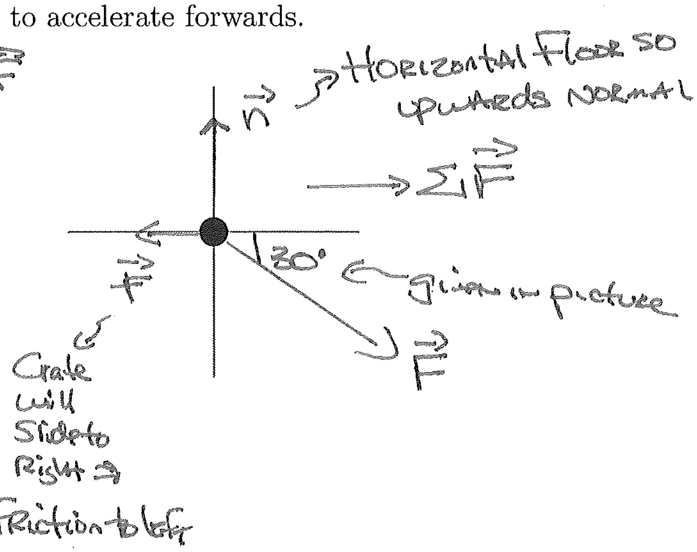
$W = (0.0125 Kg)(9.8 m/s^2) = 0.1125 N = 0.113 N$

4.7 - Free-Body Diagrams

For each of the following pictures and situations draw a free-body diagram for the object of interest. *Note:* These pictures may contain additional information that may not be necessary to include yet. Please follow all steps in Tactics Box 4.3 of the textbook.

(1.) A man pushes a crate across a rough, horizontal floor. Assume the push is large enough to cause the crate to accelerate forwards.





(2.) A motor winds in a rope that pulls the crate up the completely smooth incline. Draw the free-body diagram for the crate using "titled" axes.