Name: ____________________

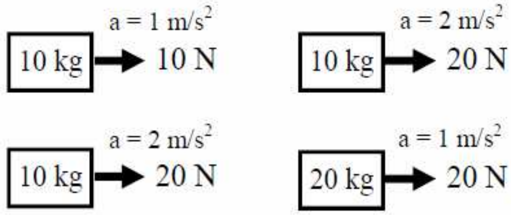
Period: ____________________

Newton's Second Law

3.3

Newton's Second Law: The acceleration of an object is proportional to the force acting on it and inversely proportional to the mass.

Increasing force increases acceleration; increasing mass decreases acceleration.



Bigger F = more a, given same mass.

More m = less a, given same force.

Newton's 2nd Law: $\Sigma F = ma$

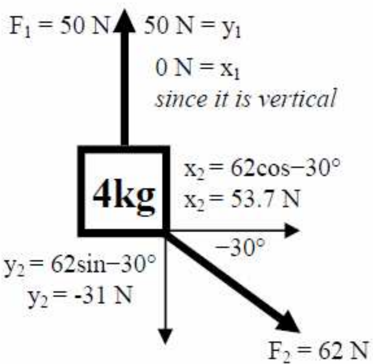
Force (*in Newtons*) → ΣF; Mass (*in kg*) → m; Acceleration (*in m/sec²*) → a

Force equals mass times acceleration.

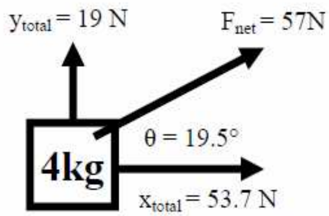
Net Force—F_{net}

We know that the acceleration is due to ALL of the forces acting on an object. The net force is the total of all of the forces. If there are forces in both dimensions, just do vector addition, as before.

1. Resolve into components



2. Calculate F_{net}



$$F_{net} = \sqrt{53.7^2 + 19^2}$$

$$F_{net} = 57\text{ N}$$

$$\theta = \tan^{-1}\left(\frac{19}{53.7}\right) = 19.5^\circ$$

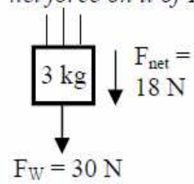
3. Use $\Sigma F = ma$.

$$57 = 4a$$

$$a = \frac{57}{4} = 14.25\text{ m/s}^2$$

Caution: NEVER add a force to F_{net}!

If F_{net} is given, then F_{net} takes the place of all of the forces (ΣF). *Ex: A 3 kg object is falling and has a net force on it of 18 N. What is the acceleration?*



Wrong! F_{net} already has F_W in it! → ~~-18 -30 = 3a~~

$$\Sigma F = ma$$

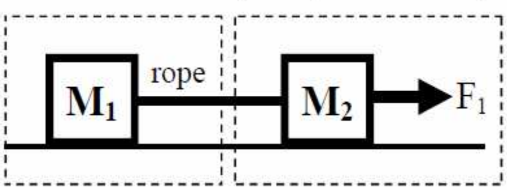
$$-18 = 3a$$

$$a = -6\text{m/s}^2$$

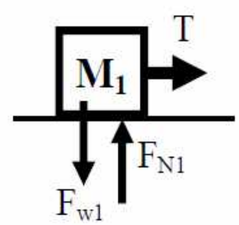
Force Diagrams

A force diagram shows all of the forces acting on an object. If there are multiple objects in a system, **you must draw a separate force diagram for each individual object.**

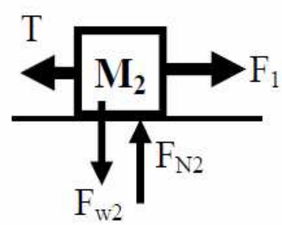
Entire System (without friction)



Individual Force Diagrams



And since they are attached by the same rope: **T = T.**



Max and May

If there are forces in both the x and y-directions, we know that we must work in the x and y-directions independently. **$\Sigma F = ma$ will look different in each direction and for each situation.**

Horizontal F = ma

$$\Sigma F_X = ma_X$$ (*horizontal acceleration*)

$$\Sigma F_X = F_{X1} + F_{X2} + \ldots$$

All horizontal forces

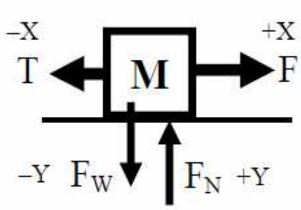
Vertical F = ma

$$\Sigma F_Y = ma_Y$$ (*vertical acceleration*)

$$\Sigma F_Y = F_{Y1} + F_{Y2} + \ldots$$

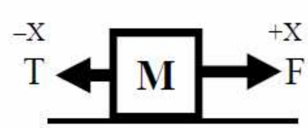
All vertical forces

Step 1—Draw the force diagram for the object.



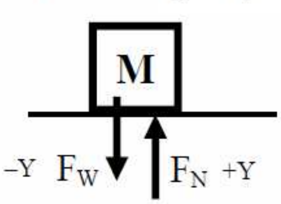
Step 2—Write the horizontal equation: $\Sigma F_X = ma_X$

$F - T = ma_X$



Step 3—Write the vertical equation: $\Sigma F_Y = ma_Y$

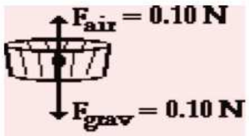
$F_N - F_W = ma_Y$



Make sure you show all your work on the problems below

Free-body diagrams are shown for a variety of physical situations. Use Newton's second law of motion ($\Sigma F = m \bullet a$) to fill in all blanks. Use the approximation that g = ~10 m/s/s.

a.

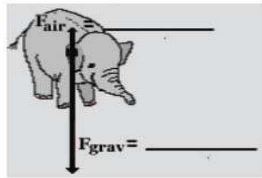


m=____________

a=____________

ΣF=____________

b.

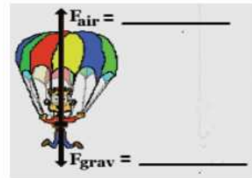


m=10000 kg

a = 8.0 m/s/s, down

ΣF = ________

c.

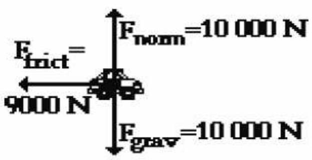


m=800 kg

a = 6.0 m/s/s, up

ΣF = ________

d.

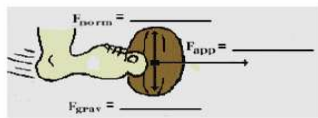


m=____________

a=____________

ΣF=____________

e.

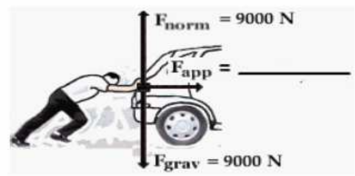


m=0.500 kg

a = ____________

ΣF = 124 N, right

f.

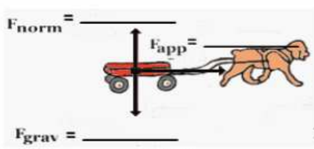


m= __________

a = 1.50 m/s/s, right

ΣF = ____________

g.

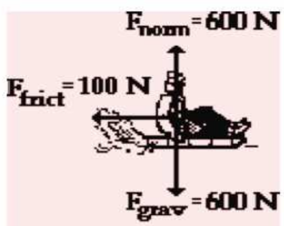


m=15.0 kg

a = 0.50 m/s/s, right

ΣF = ____________

h.

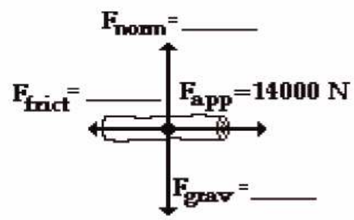


m=____________

a=____________

ΣF=____________

i.



m=2000 kg

a=2.0 m/s/s, right

ΣF=__________

Use Newton's second law to predict the effect of an alteration in mass or net force upon the acceleration of an object.

a. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 2. The new acceleration will be _________ m/s^2.

b. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 4. The new acceleration will be _________ m/s^2.

c. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon decreased by a factor of 2. The new acceleration will be _________ m/s^2.

d. An object is accelerating at a rate of 8 m/s^2 when it suddenly has its mass increased by a factor of 2. The new acceleration will be _________ m/s^2.

e. An object is accelerating at a rate of 8 m/s^2 when it suddenly has its mass decreased by a factor of 4. The new acceleration will be _________ m/s^2.

f. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 2 and its mass decreased by a factor of 4. The new acceleration will be _________ m/s^2.

g. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 4 and its mass increased by a factor of 2. The new acceleration will be _________ m/s^2.

h. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 3 and its mass decreased by a factor of 4. The new acceleration will be _________ m/s^2.