Newton's Law of Motions and 1-D Force Problems

Newton's 1st Law of Motion

- Called the Law of Inertia
- Built on the work that Galileo did for his principle of Inertia.
- Statement:

"An object will continue at a constant velocity unless acted upon by an outside net force."

Another way of saying it

"An object will stay at the same speed and move in the same direction unless acted upon by an outside net force."

Newton's Second Law of Motion

- The most important law that we use in physics.
- Statement:

"The acceleration of an object is directly proportional to and in the same direction as the applied net force and inversely proportionaly to the mass of the object."

- In formula form: $a = \frac{F_{net}}{m}$ or $F_{net} = ma$

Newton's Third Law of Motion

- Deals with the interactions between objects.
- Statement:
  "If object A exerts a force on object B, then object B exerts a force equal in magnitude but opposite in direction on object A.
- Formula: $F_A = -F_B$
- This means that for a given situation. There is a balance of forces.
- Consider this example:
- http://www.taylorphysics.org/Notes/force%20pairs/index.swf

Forces

- Push or a Pull
- Unit: Newton
- Remember Newton's Second Law gives the equation: $F_{net} = ma$

Problem Solving Process

- Read the problem at least twice
- List the given and unknown variables
- If a force and mass are given:
  - Use Newton's Second Law to find acceleration
  - Use the appropriate linear motion equation to find the unknown variables
- If no force and/or mass given,
  - Use the appropriate linear motion equation to find acceleration.
  - Use Newton's Second Law to find the missing force or mass.

Problems

- What is the weight of a 3 kg mass?
- Weight is the near earth gravitational force.
- Remember Newton's second law…
- We have been using the acceleration due to gravity g=9.8 m/s2.
- Weight is a force W=F
- W=ma and g is an acceleration SO….
- W=mg.
- This means the weight of a 3 kg mass is:

  W=(3)(9.8) = 29.4 N

Example Problem

A 1500 kg car is driving 30 m/s. The brakes are applied and the car comes to a stop over a 50 meter distance. What force did the brakes exert on the car?

$m = 1500kg$
$v_o = 30m/s$
$v = 0m/s$
$x = 50m$
$F = ?$

$$v^2 = v_o^2 + 2ax$$
$$0^2 = 30^2 + 2a(50)$$
$$0 = 900 + 100a$$
$$-900 = 100a$$
$$-9m/s^2 = a$$
$$F = ma$$
$$F = 1500(-9)$$
$$F = -13500N$$

Force Problems

- Example:

A 3.5 kg. mass is travelling at a constant velocity of 25 m/s. What force is required to slow it to a stop in 5 seconds?

$Givens:$
$v_o = 25m/s$
$v = 0m/s$
$t = 5\sec$
$m = 3.5kg$

$$v = v_o + at$$
$$0 = 25 + a(5)$$
$$-25 = 5a$$
$$-5m/s^2 = a$$

$$F_{net} = ma$$
$$F_{net} = 3.5(-5)$$
$$F_{net} = -17.5N$$

Problem for you

- A motorcyclist of mass 40kg rides a bike of 60kg. As he sets off from the lights, the forwards force is 200N. How fast will he be travelling after 5 seconds?

$m_{man} = 40kg$
$m_{cycle} = 60kg$
$F = 200N$
$v_o = 0m/s$
$t = 5sec$
$v = ?$

$$F = ma$$
$$200 = (40+60)a$$
$$2m/s^2 = a$$

$$v = v_o + at$$
$$v = 0 + 2(5)$$
$$v = 10m/s$$

Linear Motion Force Problem

- A 70 kg skier goes from rest to 12m/s down a 50 m incline. What is the net force on the skier?

  100.8 N
- A 3 kg rock falls in a vacuum. What is the force of gravity on the rock? (Vacuum means no air resistance)

  29.4 N
- A car's engine produces a force of 12000 N. It goes from 5 m/s to 25 m/s in 2 seconds. What is the mass of the car?

  1200 kg

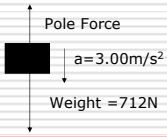
Free Body Diagram Problems

Free Body Diagram Problems

- Read the problem.
- Draw a free body diagram of the object including all the forces acting on it.
- Using the direction of motion, (acceleration or velocity) determine the direction of the "Go Forces."
- Write a Net Force equation including all the forces and find any variables that you might need (mass or weight).
- Set your net Force equation = ma and solve for the missing information.

Example Problem

A firefighter slides down the fire pole. The weight of the firefighter is 712 N, and her acceleration is 3.00 m/s². What upward force does the pole exert on her?



W=mg
712=m(9.8)
m=72.7 kg

F_{go}-F_{slow}=ma

W-P=ma

712-P =72.7(3)

712-72.7(3) =P

712-218 = P

494 N = P

Example Problems for you

- A 2.5 kg rock is falling to earth with an acceleration of 3.5 m/s². What force of air resistance is acting on the rock?

  F=15.75 N

- A 1500 kg car is experiencing a head wind of 2800 N. What is the minimum force that must be generated by the engine to overcome the head wind?

  F =2800 N

- A 1200 kg car is experiencing a frictional force of 3500 N and a tail wind of 1800 N. It can accelerate at 4 m/s². What is the force generated by the engine?

  F=6500 N

Force Problems

With Free Body Diagrams and
Linear Motion Equations

Example Problem

A firefighter slides down the fire pole. The weight of the firefighter is 712 N. At the top of the pole she starts from rest. At the bottom of the 3.5 m high pole, her velocity is 4.58 m/s. What is the firefighter's mass? What is her acceleration? What is the firefighters net force? What upward force does the pole exert on her?

W=mg
712=m(9.8)
m=72.7 kg

$v^2 = v_o^2 + 2ax$

$4.28^2 = 0 + 2a(3.5)$

$18.3 = 7a$

$\frac{18.3}{7} = a$

$2.62 m/s^2 = a$

F_{go}-F_{slow}=F_{net}

W-P=F_{net}

W-P=ma

712-P =72.7(2.62)

712-72.7(2.62) =P

712-190 = P

522 N = P

2-D Force Problems

Apply the 2-D Skills
Perform linear motion functions

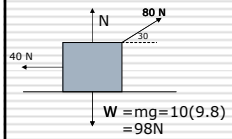
Problem Solving Processes

- Look at the situation and determine if the object will move in both the x and y planes
- Break each force into their X and Y Components
- Find the net X and Y forces
- Use right triangle math to find the net force.
- Use Newton's 2nd Law and Linear motion equations to find the final answers.

Example Problem

An 10 kg object is pulled along the floor with a force of 80 N directed at an angle of 30 degrees above the horizontal. There is a 40 N Frictional force between the floor and the object.

- What is the net horizontal force?
- What is the net force?
- What is the acceleration of the object?



V=80sin30 =40N

H =80cos30 =69.3 N

ΣF_x=H-40=69.3-40=29.3N

ΣF_y=N+V-W=0

N=W-V=98-40=58 N

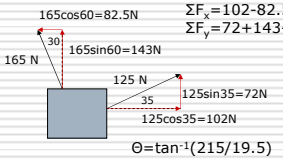
F=ma

29.3=10a

2.93m/s^2=a

2 D Forces

Two boys push on a box. One pushes with a force of 125 N at 35 degrees north of east. The other exerts a force of 165 N to the 30 degrees west of north. What is the size and direction of the resultant force on the box?



$\Sigma F_x = 102 - 82.5 = 19.5$ N

$\Sigma F_y = 72 + 143 - 0 = 215$ N

$F_{net}^2 = F_x^2 + F_y^2$

$F_{net}^2 = 19.5^2 + 215^2$

$F_{net}^2 = 380 + 46225$

$F_{net}^2 = 46605$

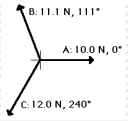
$F_{net} = 216$N

$\Theta = \tan^{-1}(215/19.5)$

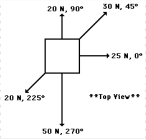
$\Theta = 84.8°$

2 D Problems for You

What is the net force acting on the objects?
If the mass of each of these is 2 kg, how far (magnitude and direction) would each of these travel in 10 seconds? If they start at 3 m/s, how fast would they be going in 10 seconds?



0.0369 N @ -36.8°
0.922 m @ -36.8°
3.18 m/s @ -36.8°



39.4 N @ -35.5°
985 m @ -35.5°
200 m/s @ -35.5°