

Forces

Physics of Motion

- **Kinematics** - study of HOW objects move. Galileo described motion but did not try to explain
- **Dynamics** - study of WHY objects move. Newton developed three important laws of motion. Each
- **Force**
 - Push
 - Vector quantity - magnitude and
 - Free Body Diagram - shows all the forces

- F_f -
- F_W -
- F_T - Tension on a
- F_N - normal force - the sum of the forces acting perpendicular
- F_{app} - applied force that is applied to an object by another object or by a
- **Balanced Force** - the sum of all forces acting on an object
- **Net Force** - the sum of all the forces acting on an object can be represented by a resulting force. The resulting force has the same affect as all the
- Force has units of
-

Four Fundamental Forces in Nature

- Strong Nuclear
 - Strongest force
 - Operates only over short distances - less
 - Holds protons and neutrons together in the nucleus
 - Responsible for nuclear
- Electromagnetic
 - 2nd strongest
 - Responsible for all electrical and
 - Charged particles create an electric field
 - Charged particles create a magnetic field when
 - Electrons in orbit in the electron clouds when in

- Weak Nuclear
 - Responsible for
- Gravitational
 - Weakest of all the
 - Force of attraction between
 - Causes weight, keeps planets orbiting around the sun,
 - Depends on the mass of the two objects and the distance between the

Newton's 1st Law of Motion

- Inertia - property of an object that makes it
 - Depends on the
 - Mass
 - Measure inertia by the amount of force required to cause a change in the
- ***Newton's 1st Law of Motion***
 - "Law of
 - An object at rest (not moving) will stay at rest until a net force acts
 - An object moving at a constant velocity (same speed and same direction) will keep moving at that velocity until a

- Balanced forces do not change an objects motion. Net
- A rock in space will keep moving at a constant velocity because nothing is
- A car moves at a constant velocity because the force of the engine is balanced with the force of friction
- You could go through the windshield during an accident because of your inertia if nothing is holding

Newton's 2nd Law

- A net force causes an object to
- Acceleration is directly proportional to the net force and inversely

-
- $F_{\text{Net}} =$
- $F_{\text{Net}} =$ Forces acting on an object parallel to the motion of the object.
- Acceleration is in the same direction as the

- F_{Net}
 -
- mass
 -

Newton's 3rd Law

- For every action force there is an equal but
- Forces come in pairs - same magnitude but
- $-F_{\text{action}} =$
- $-(m_a a_a) =$
- Accelerations are not necessarily equal - depends on
-

Newton's Laws and Seatbelts

- If you do not wear your seat, you keep going when the car stops
- Please, wear
- Please do not drink alcohol - it is against the law to drink
- If you are 21 - do not

1. A tow rope is used to pull a 1750 kg car giving it an acceleration of 1.35 m/s^2 . What force does the rope exert?
2. A racing car undergoes a uniform acceleration of 4.0 m/s^2 . If the net force causing the acceleration is 300.0 N, what is the mass of the car?
3. A 5.2 kg bowling ball is accelerated from rest to a velocity of 12 m/s as the bowler covers 5.0 m of approach before releasing the ball. What force is exerted on the ball during this time?
4. When a 22 kg child steps off a 3.0 kg stationary skateboard with an acceleration of 0.50 m/s^2 , with what acceleration will the skateboard travel in the opposite direction?

Using Newton's Laws

Mass

- Amount of
- Measure mass with a balance - compare to a standard. Gravitational
- Measure mass by the amount of force required to cause a
 - $F_{\text{Net}} =$
 -
 - Inertial

Weight

- Weight is a force,
- Units are
- Attraction between an
- Weight = mass
- $F_W =$
- Vector quantity;
- 1.00 kg mass has a weight of
 - $F_W = 1.00\text{kg}$

Friction

- Force that allows you to
- Force that opposes the slipping of two objects that
- The two surfaces have an electromagnetic
- Microscopic bumps that retards an
- Depends on :
 - Types of
 - Force pushing the surfaces
- Friction = Coefficient of friction
- $F_f =$
- Normal Force,
 - Force that is
 - Calculate
 - Usually involves
- Coefficient of friction,
 - No units,
 - Experimental
 - Depends on the
- Static Friction
 - Force that opposes the start
 -
 - Objects have a longer time for the "electrostatic"
- Sliding Friction
 - Force that opposes
 -
 - Objects are not in

Horizontal Motion

- $F_{\text{Net}} =$
- $F_{\text{Net}} =$
- Free Body Diagram :

- $F_{net} =$
- $ma =$
-
-
- $ma =$
- If velocity is constant
 - acceleration =
 - $F_{Net} = ma =$
 - $F_{Net} = 0 =$
 - Applied force is overcoming
- If you "lock" your
 - $F_{app} =$
 - $F_{Net} =$
 - $ma =$
 - $ma =$
 - $ma =$
 - $a =$
 - Mass does not matter! Just the
 - As the mass increases so
- *No real "formula" - you have to draw the free-body diagram and determine what forces are*
- *Avoid forcing a problem into the form just given - physics problems will seldom*
- *Use your understanding to work towards the*
- *Draw these Diagrams - a picture will help you develop*

Vertical Motion

- $F_{Net} =$
- $F_{Net} =$
- Free Body Diagram :

- $F_{Net} =$
- $ma =$

- If constant velocity :
 - acceleration =
 - $F_{\text{Net}} = ma =$
 - $F_{\text{Net}} = 0 =$
 - Applied force is overcoming
- $F_{\text{app}} >$
 - accelerate
- $F_{\text{app}} <$
 - accelerate
- If $F_{\text{app}} =$
- $F_{\text{Net}} =$
- $ma =$
- $a =$
- Freefall, feel
- Falling at
- Only force on you is

Drag Force

- Drag Force :
 - air molecules create
 - depends on the size and shape of the object, air density, and
- Terminal Velocity
 - constant velocity of a
 - acceleration =
 - $F_{\text{drag}} =$

5. A proton has a mass of 1.672×10^{-27} kg. What is its weight?

6. A force of 21.0 N accelerates a 9.0 kg wagon at 2.0 m/s^2 along a sidewalk. Calculate the coefficient of friction between the wagon and the sidewalk.

7. A 2.0 kg brick has a coefficient of kinetic friction of 0.38. What force must be applied to the brick for it to move at a constant velocity?

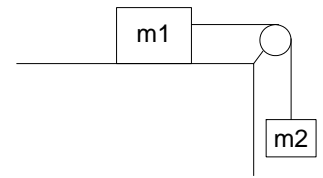
8. A brick layer applies a force of 100.0 N to each of 2 handles of a wheel barrow. Its mass is 20.0 kg and it is loaded with 30 bricks, each of mass 1.50 kg. The handles of the wheelbarrow are 30.0° from the horizontal and the coefficient of sliding friction is 0.20. What is the acceleration of the wheelbarrow?

9. Fred is pulling Mable in a wagon. He is so strong that he pulls her with a force of 75 N at an angle of 35° . Mable and the wagon together have a mass of 45 kg. If the coefficient of friction is 0.10, how fast is she accelerating?

10. In bench pressing 100.0 kg, a weight lifter applies a force of 1040 N. How large is the upward acceleration of the weights during the lift?

11. An elevator that weighs 3000.0 N is accelerated upward at 1.0 m/s^2 . What force does the cable exert to give this acceleration?

12. A 10.0 kg mass (m_1) on a frictionless table is accelerated by a 5.0 kg mass (m_2) hanging from the table. What is the magnitude of the acceleration for the mass on the table?



Inclined Planes

Inclined Planes

- Used to help
- Makes the job of moving a heavy

- F_w = Weight caused by
- Normal Force, F_N
- Force that is perpendicular to the incline
 - Supports the weight on the incline
 -
 -
 -
 -
 - Used when calculating friction

- Parallel Force , F_x
 - Force that will cause the object to
 - This force acts parallel to the
 -
 -
 - This force is used as part of F_{Net} because it will cause the object to accelerate

- As the angle () of the inclined plane increases:
 - F_x increases (inclined plane becomes more vertical) : more acceleration
 - F_y decreases (inclined plane becomes less horizontal) : less

- Suppose the object is sliding
- Friction is going in the
- $F_{Net} =$
- $m \cdot a =$
- $m \cdot a =$
- $m \cdot a =$
- $m \cdot a =$
- $a =$

- Suppose the object "sits" on the
 - $F_{\text{Net}} = 0$: Static Friction holds
 - $F_{\text{Net}} =$
 - $0 =$
 - $0 =$
-
- You can determine the static coefficient of friction by the angle an object just begins to slip down.
13. A mass, m starts from rest and slides down a frictionless incline of 30.0° . As it leaves the incline, its speed is 24 m/s .
- a. What is the acceleration of the mass while on the incline?
 - b. What is the length of the incline?
 - c. How long does it take the mass to reach the floor after it leaves the top of the incline?

14. A cable has a tension of 10,000 N on it while connected to a car. The car is being pulled up a loading ramp which is inclined 30.0° with the horizontal. If the car has a mass of 1500 kg, determine the acceleration of the car. The coefficient of kinetic friction is 0.12.

15. Suppose the cable in the previous problem breaks, what is the acceleration down the incline?

Equilibrium

Equilibrium

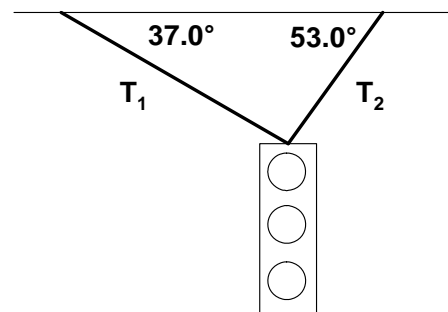
- An equilibrium force is a force that balances the resultant force and gives the object
 - Object is at rest or moving at a
 - Equilibrium force (E) is equal in magnitude but opposite in direction of the
 - Just add 180° to the
- *The sum of the horizontal forces is*
- *The sum of the vertical forces is*

16. Two forces act concurrently on a point P. A 10.0 N force is pulling at 0.0° and a 15.0 N force at 30.0° . What is the resultant force? What is the equilibrant force that would keep point P from moving?

17. A 45.0 N force is acting at 90.0° and a 56.0 N force is acting at 40.0° on a treasure chest. What is the magnitude and direction of a third force that produces equilibrium on this treasure chest?

18. A person weighs 612 N. If the person magically sits in the middle of the hammock, to form a 100.0° in the hammock, what force would be exerted by each of the two hammock ropes?

19. A traffic light weighing 100.0 N hangs from a vertical cable tied to two other cables that are fastened to a support. The upper cables make angles of 37.0° and 53.0° with the horizontal. Find the tension in each of the upper cables.



20. Five forces act simultaneously on point J (that could be anything, maybe even you). One force is 20.0 N North, 2nd is 25.0 N West, the 3rd is 10.0 N East, 4th is 10.0 N South, and the final is 15.0 N at 60.0° . Determine the magnitude and direction of the equilibrant force.