Mr. Wright's Math Extravaganza

Physical Sciences

(Chemistry, Physics, Physical Science)

Force

Units 02 Newton's Laws, 03 Uniform Circular Motion, 04 Momentum

Average Level for All Three Units

Level 2.0: 70% on test, Level 3.0: 80% on test, Level 4.0: level 3.0 and success on bumper lab

Score	I Can Statements
4.0	☐ I can design a device that minimizes force on an object during a collision and justify its design.
3.5	In addition to score 3.0 performance, partial success at score 4.0 content.
3.0	**02 Newton's Laws** ☐ I can use Newton's second law of motion to describe the mathematical relationships between net force, acceleration, and mass. **03 Uniform Circular Motion** ☐ I can explain how unbalanced forces applied to a system can cause a change in its rotational motion. **04 Momentum** ☐ I can explain how to minimize force on an object during a collision. ☐ I can explain why the total momentum of a system of objects is conserved when there is no net force on the system.
2.5	No major errors or omissions regarding score 2.0 content, and partial success at score 3.0 content.
2.0	**02 Newton's Laws** ☐ I can explain why force and acceleration are often represented with vectors. ☐ I can defend Newton's first law of motion by explaining what a balanced net force of zero means when related to objects in motion and at rest. ☐ I can explain the difference between mass and weight and their common measurement units. ☐ I can recall the equation for Newton's second law of motion. ☐ I can explain Newton's third law of motion. **03 Uniform Circular Motion** ☐ I can calculate torque on a rotating object. ☐ I can calculate how changes in the moment of inertia cause changes to its rotational velocity. **04 Momentum** ☐ I can use Newton's second law of motion and the equation for acceleration to find the relationship between impulse and momentum change. ☐ I can explain the inverse relationship between force and time using the equations for impulse and momentum change. ☐ I can explain why objects colliding for the same amount of time experience equal impulse in opposite directions, and therefore equal and opposite changes in momentum. ☐ I can recall the law of conservation of momentum. ☐ I can compare the initial and final momenta of objects in a collision.

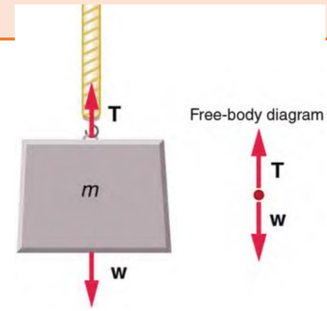
Copyrigh

	☐ I can determine the degree to which a collision is elastic or inelastic by determining whether kinetic energy is conserved. ☐ I can assess the force, momentum, impulse, and velocity associated with real-world examples of the rebound effect and elastic and inelastic collisions.
1.5	Partial success at score 2.0 content, and major errors or omissions regarding score 3.0 content.
1.0	With help, partial success at score 2.0 content and score 3.0 content.
0.5	With help, partial success at score 2.0 content but not at score 3.0 content.
0.0	Even with help, no success.

Copyright Adventist Education/Marzano's Research

Physics 02-01 Newton's Laws **Name: ___________________________**

Force



- A _____________ or a _____________
- Is a _____________
- Unit: _____________ (N)
- Measured by a ___________________________

Free-body Diagram

- Picture of object with all the _______________ acting _______ the object

Newton's First Law of Motion

A body at _____________ remains at _____________, or, if in motion, remains in _____________ at a _____________________ unless acted on by a net external _____________.

Inertia

- Property of objects to remain in _____________ motion or rest.
- _____________ is a measure of inertia

Newton's Second Law of Motion

Acceleration of a system is directly proportional to and in the same _____________ of as the net _____________ and inversely proportional to the _____________.

$$a = \frac{F_{net}}{m} \text{ or } F_{net} = ma$$

Newton's Third Law of Motion

Whenever one body exerts a _____________ on a second body, the first body experiences a force that is equal in _____________ and opposite in _____________ to the force that it exerts.

- ***Every force has an equal and opposite reaction force.***

A football player named Al is blocking a player on the other team named Bob. Al applies a 1500 N force on Bob. If Bob's mass is 100 kg, what is his acceleration?

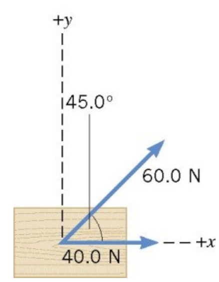
What is the size of the force on Al?

If Al's mass is 75 kg, what is his acceleration?

A 0.046 kg golf ball hit by a driver can accelerate from rest to 67 m/s in 1 ms while the driver is in contact with the ball. How much average force does the golf ball experience?

Physics 02-01 Newton's Laws	***Name: _________________________***
Practice Work	

1. Forces are vectors. Look back in previous lessons and explain how to add vectors.
2. You are riding in a car when it turns to the left abruptly. Why do you feel like you are being forced to the right?
3. Which statement is correct? (a) Net force causes motion. (b) Net force causes change in motion. Explain your answer and give an example.
4. A system can have a nonzero velocity while the net external force on it is zero. Describe such a situation.
5. An airplane has a mass of 3.1×10^4 kg and takes off under the influence of a constant net force of 3.7×10^4 N. What is the net force that acts of the plane's 78-kg pilot? (Cutnell 4.1) **93 N**
6. In the amusement park ride known as Magic Mountain Superman, powerful magnets accelerate a car and its riders from rest to 45 m/s (about 100 mph) in a time of 7.0 s. The mass of the car and riders is 5.5×10^3 kg. Find the average net force exerted on the car and riders by the magnets. (Cutnell 4.3) $\mathbf{3.5 \times 10^4}$ **N**
7. When a 58-g tennis ball is served, it accelerates from rest to a speed of 45 m/s. The impact with the racket gives the ball a constant acceleration over a distance of 44 cm. What is the magnitude of the net force acting on the ball? (Cutnell 4.5) **130 N**
8. A 1580-kg car is traveling with a speed of 15.0 m/s. What is the magnitude of the net force that is required to bring this car to a halt in a distance of 50.0 m? (Cutnell 4.6) **3560 N**
9. A person with a black belt in karate has a fist that has a mass of 0.70 kg. Starting from rest, this fist attains a velocity of 8.0 m/s in 0.15 s. What is the magnitude of the average net force applied to the fist to achieve this level of performance? (Cutnell 4.7) **37 N**
10. A 350-kg sailboat has an acceleration of 0.62 m/s^2 at an angle of 64° north of east. Find the magnitude and direction of the net force that acts on the sailboat. (Cutnell 4.12) **220 N at 64° N of E**
11. A force vector has a magnitude of 720 N and a direction of 38° N of E. Determine the magnitude and direction of the components of the force that point along the N-S line and the E-W line. (Cutnell 4.10) **440N, 570N**
12. Only two forces act on an object (mass = 3.00 kg), as in the drawing. Find the magnitude and direction (relative to the x axis) of the acceleration of the object. (Cutnell 4.13) **30.9 m/s^2 at 27.2° above *x*-axis**
13. What net external force is exerted on a 1100-kg artillery shell fired from a battleship if the shell is accelerated at $2.40 \times 10^4\ m/s^2$? What force is exerted on the ship by the artillery shell? (OpenStax 4.15) $\mathbf{2.64 \times 10^7}$ **N,** $\mathbf{2.64 \times 10^7}$ **N**
14. Find the net force for the following forces: 3 N East, 2 N West, 5 N North, and 4 N South. (RW) **1.41 N at 45° N of E**
15. Find the net force for the following forces: 10 N up and 14 N at 30° above the horizontal. (RW) **20.9 N at 54.5° above horizontal**



Physics 02-02 Weight and Normal Force — *Name:* ____________________

Weight

- Force of __________ $(F = ma)$
- Objects near earth __________ downward at 9.80 m/s^2

$$W = mg$$

- Unit: N
- Depends on local __________

Mass

- Measure of __________
- Unit: kg
- __________

Force Problem Solving Strategy

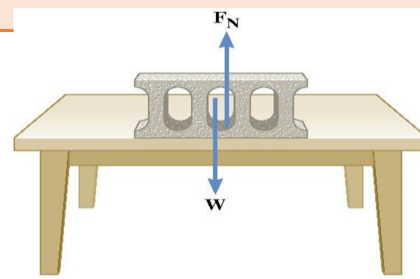
1. Identify the ________________ involved and __________ a __________
2. List your ____________ and __________ a ______________ diagram
3. Apply __________
4. Check your __________ for ________________

Free-body diagram

Draw only __________ acting _________ the object

Represent the forces with vector __________

Normal Force



- ____________________component force between two objects when they __________
- Weight pushes __________, so the table pushes __________
- Newton's __________Law
- Normal force doesn't always = weight
- Draw a ______________ diagram to find ________________

When a problem asks for apparent weight, find the __________________________

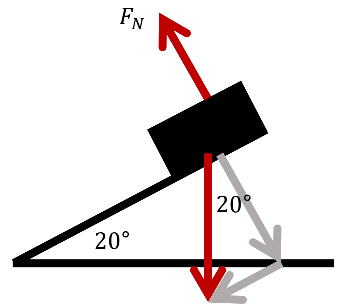
A 30-kg box of books is sitting on the floor. A 20-kg child is sitting on the box. What is the normal force between the child and the box?

What is the normal force between the box and the floor?

A lady is weighing some bananas in a grocery store when the floor collapses. If the banana's mass is 2 kg and the floor is accelerating at $-2.25\ m/s^2$, what is the apparent weight (normal force) of the bananas?

Physics 02-02 Weight and Normal Force **Name: ____________________**

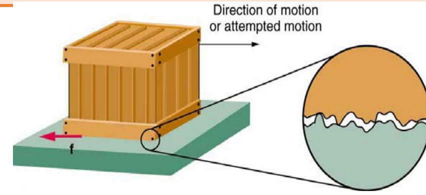
A box is sitting on a ramp angled at 20°. If the box weighs 50 N, what is the normal force on the box?



Practice Work

1. A rock is thrown straight up. What is the net external force acting on the rock when it is at the top of its trajectory?
2. When a body is moved from sea level to the top of a mountain, what changes—the body's mass, its weight, or both?
3. Object A weighs twice as much as object B at the same spot on the earth. Would the same be true at a given spot on Mars? Explain.
4. What direction is the normal force? (RW)
5. A space traveler whose mass is 115 kg leaves earth. What are his weight and mass (a) on earth and (b) in interplanetary space where there are no nearby planetary objects? (Cutnell 4.21) **m=115 kg, W=1130 N; m=115 kg, W=0 N**
6. A dumbbell weighs 200 N. What is its mass? (RW) **20.4 kg**
7. A rock of mass 45 kg accidentally breaks loose from the edge of a cliff and falls straight down. The magnitude of the air resistance that opposes its downward motion is 250 N. What is the magnitude of the acceleration of the rock? (Cutnell 4.20) **4.2 m/s²**
8. A 35-kg crate rests on a horizontal floor, and a 65-kg person is standing on the crate. Determine the magnitude of the normal force that (a) the floor exerts on the crate and (b) the crate exerts on the person. (Cutnell 4.34) **980 N, 640 N**
9. A 10-kg goat stands on a kid's back while playing. (a) What is the normal force on the goat? (b) The goat pushes down with 5 N in order to jump. What is the normal force while the goat is jumping? (RW) **98 N, 103 N**
10. A rocket blasts off from rest and attains a speed of 45 m/s in 15 s. An astronaut has a mass of 57 kg. What is the astronaut's apparent weight during takeoff? (Cutnell 4.35) **730 N**
11. A 50-kg woman is riding on an elevator. What is her apparent weight when it is accelerating upward at 1.5 m/s^2? (RW) **565 N**
12. What is the apparent weight of an 80-kg man riding tower drop ride that is accelerating at 8.9 m/s^2 downward? (RW) **72 N**
13. What is the apparent weight of a 60-kg woman that is accelerating upwards at 7 m/s^2 while being launched on a slingshot ride? (RW) **1000 N**
14. A 5-kg block rests on a frictionless plane inclined at 10°. What is the acceleration of the block as it slides down the incline? (RW) **1.70 m/s^2**
15. A 0.05-kg cookie is on a non-stick (frictionless) cookie sheet inclined at 30°. What is the acceleration of the cookie as it slides down the cookie sheet? If the cookie sheet is 0.75 m long, how much time do you have to catch the cookie before it falls off the edge (Note: This is a review question.)? (RW) **4.9 m/s^2, 0.55 s**

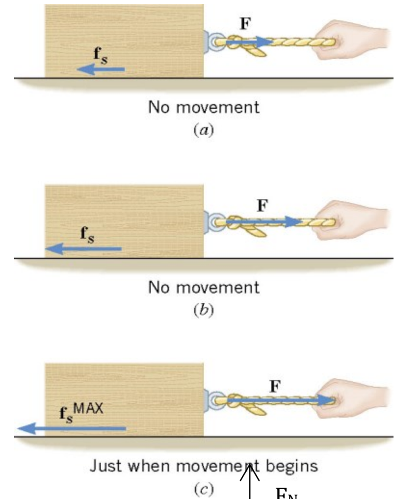
Physics 02-03 Friction **Name: ______________________**



Normal force – ________________________ to surface

Friction force – ____________ to surface, and ____________ motion

Comes from _________________________



Static Friction

Keeps things from _________.

Cancels out ___________ force until the applied force gets too _________.

Depends on force pushing _________ and _________________ of surface.

$$f_s \leq \mu_s F_N$$

μ_s is _________ _________ of static friction (0.01 to 1.5)

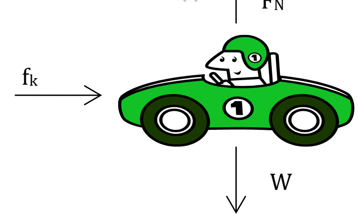
Kinetic Friction

Once motion _________

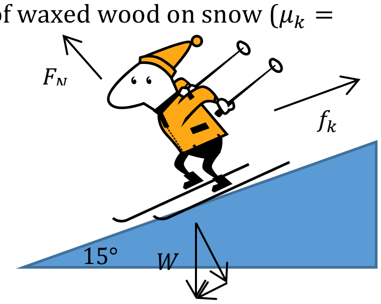
$$f_k = \mu_k F_N$$

f_k is usually _________________ f_s

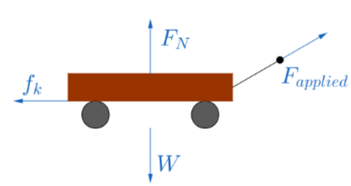
A car skids to a stop after initially going 30.0 m/s. μ_k = 0.800. How far does the car go before stopping?



A 65-kg skier is coasting downhill on a 15° slope. Assuming the coefficient of friction is that of waxed wood on snow (μ_k = 0.1), what is the skier's acceleration?



While hauling firewood to the house, you pull a 100-kg wood-filled wagon across level ground at a constant velocity. You pull the handle with a force of 230 N at 30° above the horizontal. What is the coefficient of friction between the wagon and the ground?



Physics 02-03 Friction	*Name: ________________________*
Practice Work	

1. A box rests on the floor of an elevator. Because of static friction, a force is required to start the box sliding across the floor when the elevator is (a) stationary, (b) accelerating upward, and (c) accelerating downward. Rank the forces required in these three situations from smallest to largest.
2. Define normal force. What is its relationship to friction?
3. When you learn to drive, you discover that you need to let up slightly on the brake pedal as you come to a stop or the car will stop with a jerk. Explain this in terms of the relationship between static and kinetic friction.
4. A block whose weight is 45.0 N rests on a horizontal table. A horizontal force of 36.0 N is applied to the block. The coefficients of static and kinetic friction are 0.650 and 0.420, respectively. Will the block move under the influence of the force, and, if so, what will be the block's acceleration? (Cutnell 4.37) **3.72 m/s²**
5. A 20.0-kg sled is being pulled across a horizontal surface at a constant velocity. The pulling force has a magnitude of 80.0 N and is directed at an angle of 30.0° above the horizontal. Determine the coefficient of kinetic friction. (Cutnell 4.39) **0.444**
6. A cup of hot chocolate is sitting on the dashboard of a car that is traveling at a constant velocity. The coefficient of static friction between the cup and the dashboard is 0.30. Suddenly, the car accelerates. What is the maximum acceleration that he car can have without the cup sliding backward off the dashboard? (RW) **2.94 m/s²**
7. An 81-kg baseball player slides into second base. The coefficient of kinetic friction between the player and the ground is 0.49. (a) What is the magnitude of the frictional force? (b) If the player comes to rest after 1.6 s, what was his initial velocity? (Review) (RW) **389 N, 7.68 m/s**
8. What is the maximum frictional force (μ =0.016) in the knee joint of a person who supports 66.0 kg of her mass on that knee? (OpenStax 5.3) **10 N**
9. Suppose you have a 120-kg wooden crate resting on a wood floor (μ_s = 0.5, μ_k = 0.3). (a) What maximum force can you exert horizontally on the crate without moving it? (b) If you continue to exert this force once the crate starts to slip, what will its acceleration then be? (OpenStax 5.4) **588 N, 1.96 m/s²**
10. (a) If half of the weight of a small 1.00×10^3 kg utility truck is supported by its two drive wheels, what is the maximum acceleration it can achieve on dry concrete ($\mu_s = 1.0$)? (b) Will a metal cabinet lying on the wooden bed of the truck slip if it accelerates at this rate ($\mu_s = 0.5$)? (OpenStax 5.5) **4.9 m/s², No**
11. Calculate the deceleration of a snow boarder going up a 5.0° slope assuming the coefficient of friction for waxed wood on wet snow ($\mu_k = 0.1$). (OpenStax 5.10) **1.83 m/s²**
12. (a) Calculate the acceleration of a skier heading down a 10.0° slope, assuming the coefficient of friction for waxed wood on wet snow ($\mu_k = 0.1$). (b) Find the angle of the slope down which this skier could coast at a constant velocity. (OpenStax 5.11) **0.737 m/s², 5.71°**
13. A contestant in a winter sporting event pushes a 45.0-kg block of ice across a frozen lake as shown in the picture ($\mu_s = 0.1, \mu_k = 0.03$). (a) Calculate the minimum force F he must exert to get the block moving. (b) What is its acceleration once it starts to move, if that force is maintained? (OpenStax 5.18) **51.0 N, 0.719 m/s²**

Physics 02-04 Tension, Hooke's Law, and Equilibrium Name: ____________________

Hooke's Law

For _____________ or forces that _____________ (change shape)
For _____________ deformations (no permanent change)

$$F_S = k\Delta x$$

$k =$ ______________________________ and is unique to each spring
$\Delta x =$ the _____________ the spring is stretched/compressed
Hooke's Law is the reason we can use a _____________ scale to measure _____________

Tension

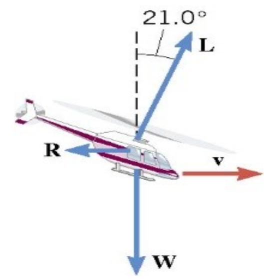
_____________ force from rope, chain, etc.
_____________ the rope connects to something, there is an _____________ tension

Equilibrium

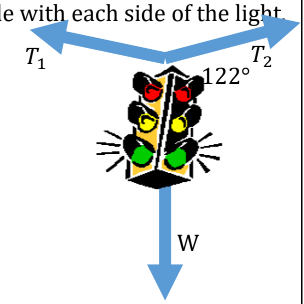
No _____________

$$F_{net} = ma \rightarrow F_{net} = 0$$

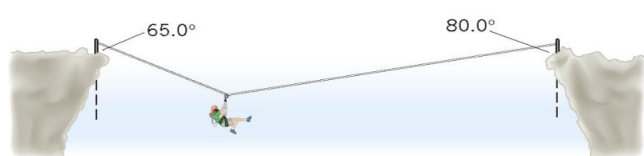
The helicopter in the drawing is moving horizontally to the right at a constant velocity. The weight of the helicopter is 53,800 N. The lift force L generated by the rotating blade makes an angle of 21.0° with respect to the vertical. What is the magnitude of the lift force?



A stoplight is suspended by two cables over a street. Weight of the light is 110 N and the cables make a 122° angle with each side of the light. Find the tension in each cable.



A mountain climber, in the process of crossing between two cliffs by a rope, pauses to rest. She weighs 535 N. Find the tensions in the rope to the left and to the right of the mountain climber.



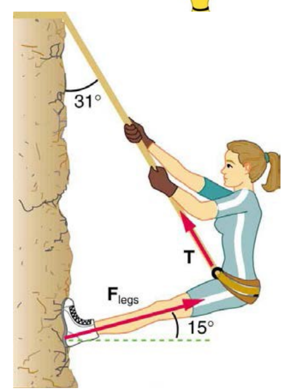
A 10-g toy plastic bunny is connected to its base by a spring. The spring is compressed and a suction cup on the bunny holds it to the base so that the bunny doesn't move. If the spring is compressed 3 cm and has a constant of 330 N/m, how much force must the suction cup provide?

Physics 02-04 Tension, Hooke's Law, and Equilibrium *Name: ______________________*

Practice Work

1. A stone is thrown from the top of a cliff. As the stone falls, is it in equilibrium?
2. During the final stages of descent, a sky diver with an open parachute approaches the ground with constant velocity. The wind does not blow him from side to side. Is the sky diver in equilibrium, and if so, what forces are responsible for the equilibrium?
3. A supertanker ($m = 1.70 \times 10^8$ kg) is moving with a constant velocity. Its engines generate a forward thrust of 7.40×10^5 N. Determine (a) the magnitude of the resistive force exerted on the tanker by the water and (b) the magnitude of the upward buoyant force exerted on the tanker by the water. (Cutnell 4.47) $\mathbf{7.40 \times 10^5}$ **N,** $\mathbf{1.67 \times 10^9}$ **N**

4. A stuntman is being pulled along a rough road at a constant velocity, by a cable attached to a moving truck. The cable is parallel to the ground. The mass of the stuntman is 109 kg, and the coefficient of kinetic friction between the road and him is 0.870. Find the tension in the cable. (Cutnell 4.51) **929 N**
5. (a) Calculate the tension in a vertical strand of spider web if a spider of mass 8.00×10^{-5} kg hangs motionless on it. (b) Calculate the tension in a horizontal strand of spider web if the same spider sits motionless in the middle of it. The strand sags at an angle of 12° below the horizontal. (OpenStax 4.19) $\mathbf{7.84 \times 10^{-4}}$ **N,** $\mathbf{1.89 \times 10^{-3}}$ **N**
6. Superhero and Trusty Sidekick are hanging motionless from a rope. Superhero's mass is 90.0 kg, while Trusty Sidekick's is 55.0 kg, and the mass of the rope is negligible. (a) Draw a free-body diagram of the situation showing all forces acting on Superhero, Trusty Sidekick, and the rope. (b) Find the tension in the rope above Superhero. (c) Find the tension in the rope between Superhero and Trusty Sidekick. (OpenStax 4.34)**1420 N, 539 N**



7. Consider the 52.0-kg mountain climber in the picture. (a) Find the tension in the rope and the force that the mountain climber must exert with her feet on the vertical rock face to remain stationary. Assume that the force is exerted parallel to her legs. Also, assume negligible force exerted by her arms. (b) What is the minimum coefficient of friction between her shoes and the cliff? (OpenStax 5.17) **273 N, 512 N; 0.268**
8. A monkey (m = 4 kg) is in a harness connected to a rope that goes up over a pulley on the ceiling. If the monkey pulls on the other end of the rope, it will go up. It is climbing at a constant velocity, what is the tension in the rope? (RW) **19.6 N**
9. A toy dart gun uses a spring to shoot a dart. (a) If you have to use 25 N to compress the spring by 6 cm, what is the spring constant? (b) If it fires a 50-g dart, what will be the acceleration of the dart assuming no air resistance? (RW) **417 N/m, 500 m/s²**
10. An 80-kg bungee jumper jumps off a bridge. Rubber bungee cords act as a large spring attaching the jumper to the bridge. A bear standing in the river below catches the jumper. If the spring constant of the bungees is 20 N/m and they stretch 50 m. How much force must the bear apply to keep the jumper from moving? (RW) **216 N**

Physics 02-05 Nonequilibrium and Fundamental Forces **_Name: ___________________________

Four Basic Forces

All forces are made up of only _____________ forces

- __________________________– gravity
- ____________________– static electricity, magnetism
- __________________________– radioactivity
- __________________________– keeps nucleus of atoms together

All forces occur because _____________ with that force _____________play _____________with a different ____________

- Electromagnetic uses _____________

- Scientists are trying to combine all forces together in __________________________
- Have combined ____

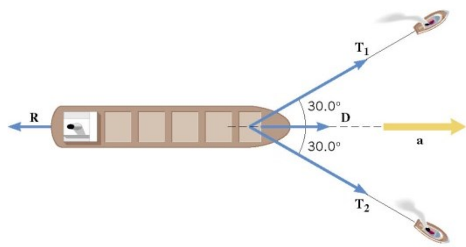
_____________ is the weakest

We feel it because the electromagnetic _____________ out over _____________ areas

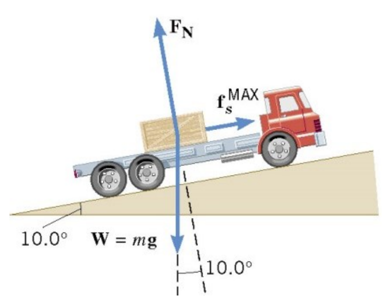
_____________ forces are _____________ but only over _____________ distance

A 1380-kg car is moving due east with an initial speed of 27.0 m/s. After 8.00 s the car has slowed down to 17.0 m/s. Find the magnitude and direction of the net force that produces the deceleration.

A supertanker of mass $m = 1.50 \times 10^8$ kg is being towed by two tugboats, as in the picture. The tensions in the towing cables apply the forces T_1 and T_2 at equal angles of 30.0° with respect to the tanker's axis. In addition the tanker's engines produce a forward drive force D, whose magnitude is $D = 75.0 \times 10^3$ N. Moreover, the water applies an opposing force R, whose magnitude is $R = 40.0 \times 10^3$ N. The tanker moves forward with an acceleration of 2.00×10^{-3} m/s². Find the magnitudes of the tensions T_1 and T_2.

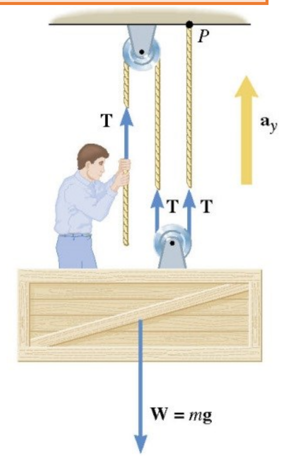


A flatbed truck is carrying a crate up a 10.0° hill as in the picture. The coefficient of the static friction between the truck bed and the crate is $\mu_s = 0.350$. Find the maximum acceleration that the truck can attain before the crate begins to slip backward relative to the truck.



Physics 02-05 Nonequilibrium and Fundamental Forces Name: ___________________________

A window washer on a scaffold is hoisting the scaffold up the side of a building by pulling downward on a rope, as in the picture. The magnitude of the pulling force is 540 N, and the combined mass of the worker and the scaffold is 155 kg. Find the upward acceleration of the unit.



Practice Work

1. A circus performer hangs stationery from a rope. She then begins to climb upward by pulling herself up, hand over hand. When she starts climbing, is the tension in the rope less than, equal to, or greater than it is when she hangs stationary? Explain.
2. Only two forces act on an object (m = 4.00 kg): 60.0 N in the $+y$ direction and 40.0 N in the $+x$ direction. Find the magnitude and direction (relative to the x-axis) of the acceleration of the object. (Cutnell 4.63) **18 m/s² at 56.3°**
3. A 292-kg motorcycle is accelerating up along a ramp that is inclined at 30.0° above the horizontal. The propulsion force pushing the motorcycle up the ramp is 3150 N, and air resistance produces a force of 250 N that opposes the motion. Find the magnitude of the motorcycle's acceleration. (Cutnell 4.68) **5.03 m/s²**
4. A rescue helicopter is lifting a man (weight = 822 N) from a capsized boat by means of a cable and harness. (a) What is the tension in the cable when the man is given an initial upward acceleration of 1.10 m/s²? (b) What is the tension during the remainder of the rescue when he is pulled upward at a constant velocity? (Cutnell 4.70) **914 N, 822 N**
5. To hoist himself into a tree, a 72.0-kg man ties one end of a nylon rope around his waist and throws the other end over a branch of the tree. He then pulls downward on the free end of the rope with a force of 358 N. Neglect any friction between the rope and the branch and determine the man's upward acceleration. (Cutnell 4.75) **0.14 m/s²**
6. A 95.0-kg person stands on a scale in an elevator. What is the apparent weight when the elevator is (a) accelerating upward with an acceleration of 1.80 m/s², (b) moving upward at a constant speed, and (c) accelerating downward with an acceleration of 1.30 m/s²? (Cutnell 4.94) **1100 N, 931 N, 808 N**
7. A 15-g bullet is fired from a rifle. It takes 2.50×10^{-3} s for the bullet to travel the length of the barrel, and it exits the barrel with a speed of 715 m/s. Assuming that the acceleration of the bullet is constant, find the average net force exerted on the bullet. (Finding the acceleration is review.) (Cutnell 4.95) **4290 N**
8. Suppose a 60.0-kg gymnast climbs a rope. (a) What is the tension in the rope if he climbs at a constant speed? (b) What is the tension in the rope if he accelerates upward at a rate of 1.50 m/s²? (OpenStax 4.20) **588 N, 678 N**
9. A 5.00×10^5-kg rocket is accelerating straight up. Its engines produce 1.250×10^7 N of thrust, and air resistance is 4.50×10^6 N. What is the rocket's acceleration? (OpenStax 4.23) **6.20 m/s²**
10. The wheels of a midsize car exert a force of 2100 N backward on the road to accelerate the car in the forward direction. If the force of friction including air resistance is 250 N and the acceleration of the car is 1.80 m/s², what is the mass of the car plus its occupants? (OpenStax 4.24) **1030 kg**
11. Calculate the force a 70.0-kg high jumper must exert on the ground to produce an upward acceleration 4.00 times the acceleration due to gravity. (OpenStax 4.25) **3430 N**
12. A nurse pushes a cart by exerting a force on the handle at a downward angle 35.0° below the horizontal. The loaded cart has a mass of 28.0 kg, and the force of friction is 60.0 N. (a) Draw a free-body diagram for the system of interest. (b) What force must the nurse exert to move at a constant velocity? (OpenStax 4.35) **73 N**

Physics Unit 2: Forces Review

1. Know about force, free-body diagrams, Newton's Laws of Motion, inertia, weight, normal force, apparent weight, static friction, kinetic friction and which is greater, tension, Hooke's Law, equilibrium, fundamental forces
2. What is the net force required to stop a 635-kg moose if it stops with a $-2.35\ m/s^2$ acceleration?
3. What is the acceleration of a 1000-kg car that stops with a braking force of 500 N?
4. A 900-kg elephant is standing on the ground. If there are no other forces, what is the normal force between the elephant and the ground?
5. Francis rides a freefall drop ride at the fair. What is her apparent weight if her mass is 60 kg and the ride is accelerating down at $8.0\ m/s^2$?
6. A 15-kg wagon is pulled across the ground with a constant speed by a rope making an 30° angle with the ground. If the pulling force is 90 N, what is the coefficient of friction between the wagon and the ground?
7. A box is sitting on a table. The coefficient of friction between the table and box is 0.4. If a 70-N horizontal force is required to slide the box across the table, what is the box's mass?
8. A 70-kg sled slides across the level ground and is slowing down due to friction. If the coefficient of friction is 0.2, what is acceleration of the box?
9. A 20-kg child sits on a spring attached to the ground. The spring is compressed 20 cm. If it is in equilibrium, what is the spring constant?
10. An elevator is hung from a cable which is attached to a pulley. If the elevator's mass is 5000 kg and it is rising with a constant velocity, what is the tension in the cable?
11. A 0.1-kg soup can is pulled behind a car by a string. If the string is horizontal and the coefficient of friction is 0.7, what is the tension in the string when the car accelerates at $3\ m/s^2$?
12. A spring with k = 5000 N/m is stopping a 2×10^5-kg train. If the spring is compressed 90 cm, what is the acceleration of the train?
13. A 5-kg monkey has a rope tied around her waist. That rope goes up to the ceiling and around a pulley. Then the rope goes back down to the monkey. The monkey pulls on the rope so that she goes up towards the ceiling. If she pulls with 30 N, what is her acceleration?

Physics Unit 2: Forces Review
Answers

2. $F_{net} = ma$

   $F_{net} = (635\ kg)\left(-2.35\frac{m}{s^2}\right) = \mathbf{-1490\ N}$

3. $F_{net} = ma$

   $500\ N = (1000\ kg)a$

   $\mathbf{0.5\frac{m}{s^2}} = a$

4. $F_{net} = ma$

   $F_N - mg = 0$

   $F_N - (900\ kg)\left(9.8\frac{m}{s^2}\right) = 0$

   $F_N = \mathbf{8820\ N}$

5. $F_{net} = ma$

   $F_N - mg = ma$

   $F_N - (60\ kg)\left(9.8\frac{m}{s^2}\right) = (60\ kg)\left(-8.0\frac{m}{s^2}\right)$

   $F_N - 588\ N = -480\ N$

   $F_N = \mathbf{108\ N}$

6. y-direction: $F_{net} = ma$

   $F_N - mg + F_{pull}\sin\theta = 0$

   $F_N - (15\ kg)\left(9.8\frac{m}{s^2}\right) + (90\ N)\sin 30° = 0$

   $F_N = 102\ N$

   x-direction: $F_{net} = ma$

   $F_{pull}\cos\theta - f_k = 0$

   $F_{pull}\cos\theta - \mu_k F_N = 0$

   $(90\ N)\cos 30° - \mu_k(102\ N) = 0$

   $-\mu_k(102\ N) = -77.94\ N$

   $\mu_k = \mathbf{0.76}$

7. y-direction: $F_{net} = ma$

   $F_N - mg = 0$

   $F_N = mg = \left(9.8\frac{m}{s^2}\right)m$

   x-direction: $F_{net} = ma$

   $F_{pull} - f_s = 0$

   $F_{pull} - \mu_s F_N = 0$

   $70\ N - 0.4\left(9.8\frac{m}{s^2}\right)m = 0$

   $\left(-3.92\frac{m}{s^2}\right)m = -70\ N$

   $m = \mathbf{17.9\ kg}$

8. y-direction: $F_{net} = ma$

   $F_N - mg = 0$

   $F_N - (70\ kg)\left(9.8\frac{m}{s^2}\right) = 0$

   $F_N = 686\ N$

   x-direction: $F_{net} = ma$

   $-f_k = ma$

   $-\mu_k F_N = ma$

   $-0.2(686\ N) = (70\ kg)a$

   $\mathbf{-1.96\frac{m}{s^2}} = a$

9. $F_{net} = ma$

   $k\Delta x - mg = 0$

   $k(0.2\ m) - (20\ kg)\left(9.8\frac{m}{s^2}\right) = 0$

   $k(0.2\ m) = 196\ N$

   $k = \mathbf{980\ N/m}$

10. $F_{net} = ma$

    $T - mg = 0$

    $T - (5000\ kg)\left(9.8\frac{m}{s^2}\right) = 0$

    $T = \mathbf{49000\ N}$

11. y-direction: $F_{net} = ma$

    $F_N - mg = 0$

    $F_N = (0.1\ kg)\left(9.8\frac{m}{s^2}\right) = 0.98\ N$

    x-direction: $F_{net} = ma$

    $T - f_k = ma$

    $T - \mu_k F_N = ma$

    $T - 0.7(0.98\ N) = (0.1\ kg)\left(3\frac{m}{s^2}\right)$

    $T - 0.686\ N = 0.3\ N$

    $T = \mathbf{0.986\ N}$

12. x-direction: $F_{net} = ma$

    $-k\Delta x = ma$

    $-\left(5000\frac{N}{m}\right)(0.9\ m) = (2\times10^5\ kg)a$

    $-4500\ N = (2\times10^5\ kg)a$

    $\mathbf{-0.0225\frac{m}{s^2}} = a$

13. $F_{net} = ma$

    $2T - mg = ma$

    $2(30\ N) - (5\ kg)\left(9.8\frac{m}{s^2}\right) = (5\ kg)a$

    $11\ N = (5\ kg)a$

    $\mathbf{2.2\frac{m}{s^2}} = a$