

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 _____

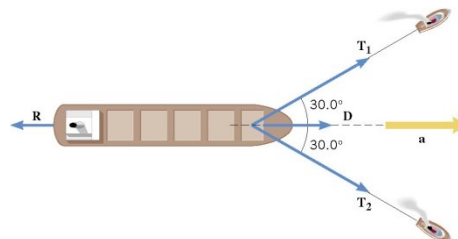
- Electromagnetic uses _____

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

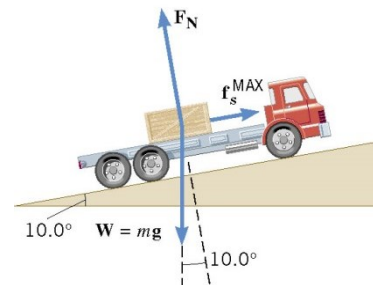
_____ is the weakest
 We feel it because the electromagnetic _____ out over _____ areas
 _____ forces are _____ but only over _____ distance

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.

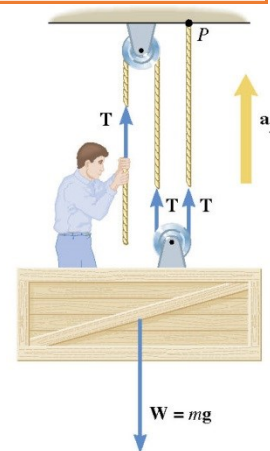
A supertanker of mass $m = 1.50 \times 10^8$ kg is being towed by two tugboats, as in the picture. The tensions in the towing cables apply the forces T_1 and T_2 at equal angles of 30.0° with respect to the tanker's axis. In addition the tanker's engines produce a forward drive force D , whose magnitude 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.



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 stationary 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**