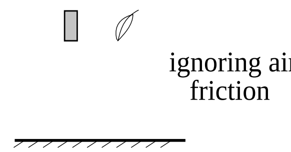
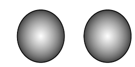
Newton's Laws -- Conceptual Questions

1.) A car moves at a constant 30 m/s. Is it accelerating? If so, must there be an applied net force to maintain this motion? Explain.



2.) Two objects of different mass will have different weights (that is, they will feel different gravitational forces), yet if air friction is ignored and you drop both from the same height, they will accelerate due to gravity at the same rate. How can this be?

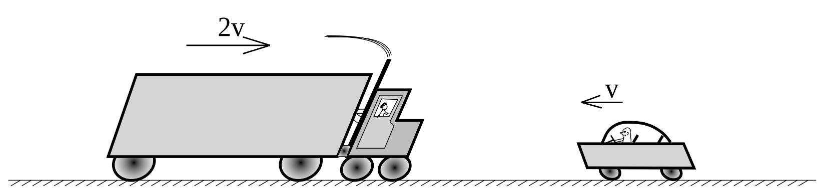


3.) A solid copper ball and a hollow copper ball of the same radius are found in space. Both are weightless. Without cutting them open, how can you determine which is which?

4.) A body is accelerated by some net force. If the force is halved, how will the velocity-change Δv alter? If the mass is halved instead, how will the velocity-change Δv alter?

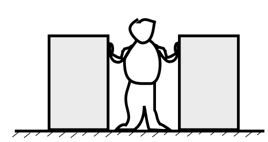
5.) It is easier to keep a crate moving across a frictional floor than it is to get it going in the first place. Why? That is, aside from the relative motion, what is the fundamental difference between the two cases?

6.) A heavy box attached to a parachute will reach the ground faster than a light box of equal size attached to an identical parachute. Why?



7.) A truck is ten times more massive and moves with twice the speed of a small car. The two collide. During the collision, which will experience the greater force? Which will experience the greater acceleration?

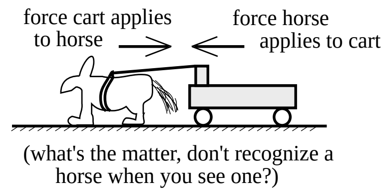
8.) A man stands wedged between two identical crates on a frictionless sheet of ice. Is there any way he can make the acceleration of one of the blocks greater than that of the other?



9.) Drop a rock from the mast of a moving boat. Will it hit the deck a.) in front of the mast, b.) next to the mast, or c.) behind the mast? Justify your response in terms of the force(s) acting on the rock.

10.) A kid steps off a footstool and begins to freefall under the influence of gravity. That is, the earth applies a gravitational force to the kid. For this situation, what is the "reaction force" alluded to in Newton's Third Law?

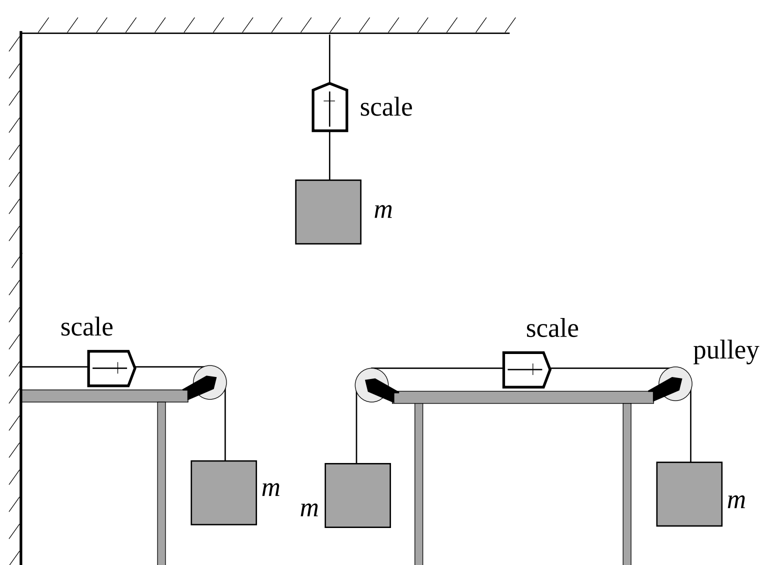
11.) A force F_1 stops a car. In terms of F_1, how large must a new force be to stop the same car under the same circumstance but in half the distance? In half the time?



12.) A horse pulls on a cart. According to Newton's Third Law, the cart must exert an equal and opposite reaction force back on the horse. That is, if the horse pulls the cart with 50 newtons of force, the cart must pull back on the horse with 50 newtons of force. As this so-called action/reaction pair always adds to zero, it appears as though we are suggesting that the cart will never accelerate. This obviously can't be the case, so what's the problem here?

13.) Assuming friction is negligible, which will reach the bottom of an incline first, a large box or a small box? Explain.

14.) An object falls from rest into a syrupy fluid. What does its *net force versus time* graph look like? Its *velocity versus time* graph? Its *position versus time* graph?



15.) Assuming all masses are the same size and the pulleys are ideal (i.e., massless and frictionless), which of the three scales in the figure will register the greatest force?

16.) A ball is dropped from rest a distance h units above a bathroom scale. When it hits, the scale measures a force of 50 newtons. The ball is then dropped from a distance $2h$ units above the scale. Will the scale read 100 newtons, less than 100 newtons, or more than 100 newtons? Explain.

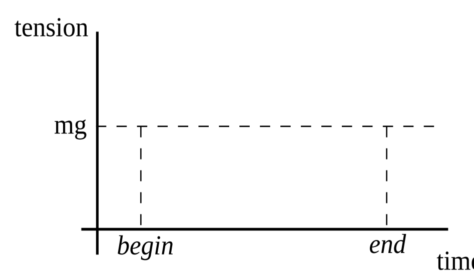
17.) A massive object is placed on a frictionless table. It takes 2 newtons of force to accelerate it at .5 m/s^2. The object is taken into space where it is weightless. The force required to accelerate the object at .5 m/s^2 will be (a) less than, (b) equal to, or (c) more than 2 newtons.

18.) Magic Mountain is an amusement park in Southern California that is known for giant roller coaster rides. One of the rides, Superman, consists of a cart that is accelerated along a horizontal stretch of track (via magnetic induction, no less) to somewhere around 100 mph in less than four seconds. The cart's path then curves into a vertical climb up an enormously high tower. At the top it comes to rest whereupon it proceeds to freefall several hundred feet back down the vertical section of the track and out the curve onto the horizontal section where it finally comes to rest. The drop from the top is billed as *pure freefall*. In theory, if you took this ride and released a dime at the top (i.e., just as you began to fall back down the track), the dime should sit motionless in front of you as both you and it gravitationally accelerated back toward Earth. For two reasons (one obvious and one not so obvious), DOING THIS WOULD BE A BAD IDEA--A REALLY, REALLY BAD IDEA. What is the obvious problem and, for the hotshots, what is the not so obvious problem?

19.) A pendulum in Los Angeles (22^o latitude) does not hang directly toward the center of the earth. Explain why not.

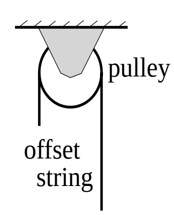
20.) A block on a frictional incline plane compresses an ideal spring by a distance *d*. The spring is released firing the block up the incline. Old George maintains that the block will go up the incline and, upon returning, will recompress the spring by some distance *less than d*. Why, in the real world, might he think that, and what additional, exotic thing might happen that could prove him wrong?

21.) A mass *m* is attached to one end of a string. The other end of the string is attached to the ceiling of an elevator. The elevator proceeds from the first floor to the sixtieth floor. What might you expect the graph of the string tension to look like, relative to the force *mg*, as the motion proceeds? Being the big-hearted guy that I am, I'll give you a hint: the tension IS *mg* before the elevator begins to move. Justify each part of your graph.



22.) A block on a horizontal frictional surface is pulled by a rope oriented at some non-zero angle, relative to the horizontal. Is there an optimal angle at which the block's acceleration will be a maximum and, if so, how would you go about theoretically determining that angle?

23.) You want to set up the following device: Place a string over a pulley, then attach unequal masses to each end (this device is called *an Atwood Machine*--typically, the question asked for such a device is *what will the acceleration of the system be if allowed to freefall?*). Unfortunately, you are

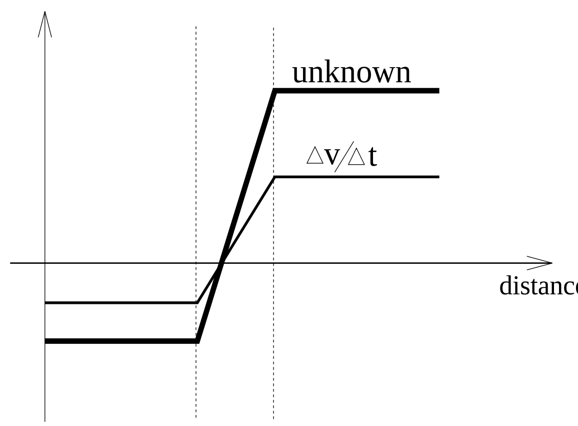


symmetrically challenged. Every time you thread the string over the pulley (i.e., before you get the masses attached), you put more string on one side of the pulley than on the other side. That means that when you release the string to pick up the masses, the string free-wheels over the pulley and ends up on the ground (really irritating).

You may be symmetrically challenged, but you aren't stupid. Realizing that you aren't going to be able to make the miserable thing work, you change the problem to *what is the <u>string's</u> freefall acceleration as it free-wheels over the pulley*? Without answering the question itself, answer the following: Will the acceleration be constant (i.e., could you use kinematics on this if you were clever?) and, if not, what parameters (i.e., height above the ground, initial velocity, what?) will determine what the string's acceleration is at a given instant?

24.) A net force of 2 newtons is applied to a mass. The speed of the object doesn't change. How can this be?

25.) The graph shown depicts an object's change of velocity with time. What might the unknown function be?



26.) John was big, but he wasn't too bright. He needed to transport several 60 pound cubical microwave cookers (each was enameled plastic with no feet) across town in his car, but his beat up, rusty hulk of a vehicle was just a little too small. To accommodate the last two, he put them side by side on the roof. Once there, he urged the car forward only to find that they both broke loose and slid when he stopped. To remedy the problem, he put one on top of the other thereby doubling the normal force thereby doubling the frictional force. What problem is he likely to run into?

27.) Three identical springs are attached at the ceiling. A bar of mass m is hooked to the group. If the new system's equilibrium position is d units below the springs' unstretched lengths, what must the spring constant be for each spring?