

Physics 110
Spring 2006
1-D Motion Problems

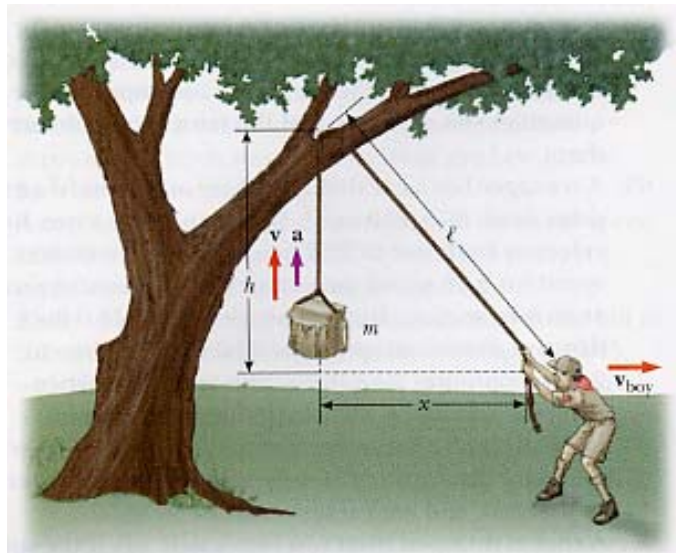
1. Jules Verne in 1865 proposed sending people to the moon by firing a space capsule from a 220-m long cannon with a final velocity of 10.97 km/s. What is the acceleration of this space capsule? Express your answer in g's, where $1\text{ g} = 9.8\text{ m/s}^2$.
2. The minimum distance required to stop a car moving at 35 mi/hr is 40ft. What is the minimum stopping distance for the same car moving at 70 mi/hr assuming the same rate of deceleration?
3. A large jet plane lands with a speed of 100 m/s and can decelerate at a maximum rate of 5 m/s^2 as it comes to rest.
 - a. From the instant the plane touches down on the runway, what is the minimum time needed before the plane will come to rest?
 - b. Could this plane land on a runway that is 2539 feet long?
4. You are driving at 30 m/s when you enter a one-lane tunnel. As soon as you enter you notice a slow moving van 155m ahead traveling at 5 m/s. If you apply the brakes, but can only decelerate at a 2 m/s^2 because the road is wet, will you collide with the van? If so, how far from the tunnels entrance will the collision occur? If there will be no collision, what is the closest distance you come to the van?
5. A student throws a set of keys vertically upward to her sorority sister, who is in a window 4m above. The keys are caught 1.5 seconds later by the sister's outstretched hand.
 - a. With what initial velocity were the keys thrown?
 - b. What was the velocity of the keys just before they were caught?
6. A commuter train travels between two downtown stations. Since the stations are only 1 km apart the train never reaches the maximum possible cruising speed. The engineer minimizes the time t between the two stations by accelerating at a rate of 0.1 m/s^2 for a time t_1 and then by braking with an acceleration of -0.5 m/s^2 for a time t_2 . What is the minimum time of travel t and the time t_1 ?
7. A rock is dropped from rest into a well.
 - a. If the splash is heard 2.4s later, how far below the top of the well is the water's surface? (The speed of sound in air is 343 m/s.)
 - b. If the travel time for the sound is neglected, what percentage error is introduced when the depth of the well is calculated?

8. To protect his food from hungry bears, a boy scout raises his food pack with a rope that is thrown over a tree limb at a height h above his hands. He walks away from the vertical rope with a constant velocity v_{boy} , holding the free end of the rope in his hands as shown below.

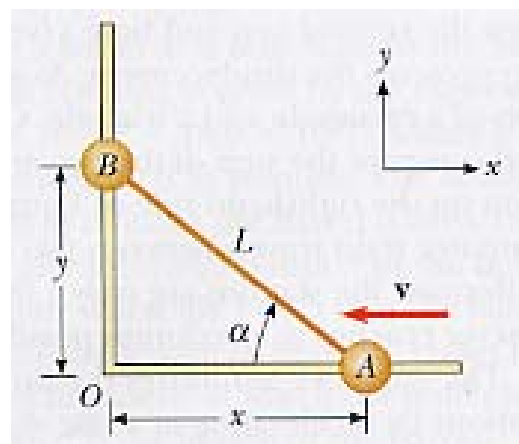
- a. Show that the speed v of the food pack is given as $v = v_{boy} \frac{x}{\sqrt{x^2 + h^2}}$.
- b. Show that the acceleration of the food pack is $a = v_{boy}^2 \frac{h^2}{(x^2 + h^2)^{\frac{3}{2}}}$. (Hint:

This part uses calculus, do it for fun if you'd like!!)

- c. What values do the acceleration and velocity have shortly after the boy leaves the point under the pack, at $x = 0$?
- d. What values do the pack's velocity and acceleration approach as the distance x continues to increase?



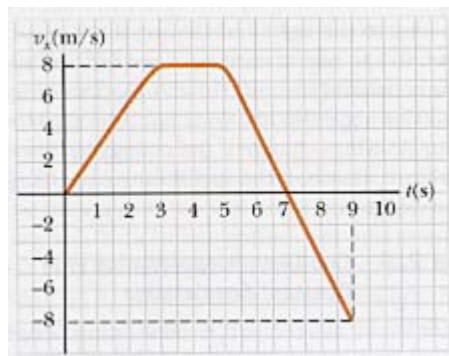
9. Two objects A and B are connected by a rigid rod that has a length L . The objects slide along perpendicular guide rails as shown below. If A slides to the left with constant speed v , find the speed of B when $\alpha = 60^\circ$. (HINT: This problem uses Calculus – do it for fun if you'd like!!)



10. Astronauts on a distant planet toss a rock into the air. With the aid of a camera that takes pictures at a steady rate, they record the height of the rock as a function of time. The values are given in the table below.
- What is the average velocity of the rock in the time intervals between each measurement and the next?
 - Using these average velocities to approximate the instantaneous velocities at the midpoints of the time intervals, make a graph of velocity versus time. Does the rock move with a constant acceleration?
 - If the answer to *b* is yes, what is the acceleration of the rock?
 - What is the acceleration of the rock in *g*'s?

Time (s)	Height (m)	Time (s)	Height (m)
0.00	5.00	2.75	7.62
0.25	5.75	3.00	7.25
0.50	6.40	3.25	6.77
0.75	6.94	3.50	6.20
1.00	7.38	3.75	5.52
1.25	7.72	4.00	4.73
1.50	7.96	4.25	3.85
1.75	8.10	4.50	2.86
2.00	8.13	4.75	1.77
2.25	8.07	5.00	0.58
2.50	7.90		

11. A student drives a motorcycle along a straight road as described by the velocity-time graph shown below.
- Draw the position versus time graph corresponding to the motion of the motorcycle.
 - Draw the acceleration versus time graph corresponding to the motion of the motorcycle.
 - What is the acceleration at $t = 6\text{s}$?
 - Find the position of the particle (relative to the starting point) at $t = 6\text{s}$.
 - What is the motorcycle's final position at $t = 9\text{s}$?



12. A speeder moves at a constant 15 m/s in a school zone. A police car starts from rest just as the speeder passes it. The police car accelerates at 2 m/s^2 until it reaches a maximum velocity of 20 m/s . Where and when does the speeder get caught?