Chapter 7

A Good Thing to Know

There are three kinds of momentum problems. They are as follows:

a) Two things stick together:

$m_1v_1 + m_2v_2 = (m_1+m_2)v_f$

b) Something blows up:

$(m_1+m_2)v_i = m_1v_1 + m_2v_2$

c) Two things collide elastically:

$m_1v_1 + m_2v_2 = m_1'v_1' + m_2'v_2'$

1. Momentum = mass x velocity. (p = mv) You are given mass and velocity. Convert the mass to kilograms and solve for momentum.

4. This is a "something blows up" momentum problem. The original mass is not moving and consists of two parts. One part then moves to the right (+ velocity), what happens to the rest?

5. This is a "unit" problem. The units for force are kgm/s^2. You have kg/s and m/s.

6. This is a "two things stick together" problem. Both original objects are moving in the same direction, so you can make both velocities (+).

8. This is a "two things stick together" problem, where the second object has no initial velocity.
   You'll need to perform basic algebraic wizardry to solve for the mass of the second car.

9. If you multiply the wind velocity (convert it to m/s) times the mass per second (kg/s) you will get kgm/s^2, which are units for impulse force. The mass per second however, is given per square meter, so you will have to multiply by the surface area of the person (given in terms of width x height) to get the total mass per second of the wind on him. Then calculate impulse force.

   Next, using the mass of the mass of the person and the coefficient of friction given, calculate the force of friction on the person and compare that to the force of the wind. Will he be blown over?

10. This is a "two things sticks together" problem where the second object (snow) has no initial horizontal velocity. Find the total mass of the snow using the rate at which it falls in m/s and the total time it fell. Then solve for v_f.

11. This is a "something blows up" problem where the original mass has a velocity. They don't give you the mass of the daughter nucleus (what's left after the alpha particle is emitted) but you can determine that from the mass of the original nucleus and the alpha particle. List your variables and solve for the velocity of the alpha particle.

13. This is a something-blows-up problem, and one of many where you have 2 unknowns and two equations to solve for them. You are given the initial mass, the initial velocity and, indirectly, the masses of m_1 and m_2 once the rocket separates. You are given the relative velocity of the two sections of the rocket to each other after the explosion. The sum of the actual velocities equals the relative velocities. Use this information to solve for the velocity of the first section in terms of the relative velocity and the velocity of the second section. Now use the something-blows-up equation using the given masses and substituting subsequent velocities so that you have v_1 expressed in terms of v_2. Then solve for v_2.

15. a) Take Δv to be 45m/s. b) Use Newton's 3rd Law to solve this one.

16. Impulse = $\frac{m\Delta v}{time}$. Convert milliseconds (ms) to seconds.
Impulse force = Impulse times time.

19. a) Momentum is mass x velocity.
b) Impulse is momentum divided by time.
c) Momentum is always conserved. If the fullback was stopped, his momentum and therefore his impulse was transferred to the tackler.
d) F = ma. You have v_o, v and time. Choose from VAT, VAX or VATX to find a.

20. a) Impulse is the area under the curve of a F vs time graph. The graph is at the top of the page.
b) You know the impulse, the mass and the initial velocity. Find the final velocity.

23. You'll probably need a full sheet of paper for this one because you have two variables and will need two equations to solve for them. Use the momentum equation for a perfectly elastic collision and solve for v_1 in terms of v_2. Plug that into the conservation of kinetic energy equations for a perfectly elastic equation and solve for v_2. Plug your value for v_2 into your first momentum equation and solve for v_1.

29. This problem will take 3 steps.
   i) Use conservation of energy to find the velocity of block M as it strikes block m at the bottom of the ramp.
   ii) Use the perfectly elastic collision equation to determine the velocities of blocks M and m after the collision.
   iii) Now use time to fall and the distance equation to determine where each cube lands.

32. Long way: This is a “two things sticks together” problem where the second object has no initial velocity. List your variables and solve for v_f. The kinetic energy of the pendulum + bullet traveling at v_f will become potential energy when the pendulum has risen the vertical distance, h as shown below. Set these equations equal and solve for h. Subtract that from the length of the pendulum to find the vertical leg of your right triangle, and the use the Pythagorean theorem to find the horizontal leg.

Short way: Use the equation for velocity of a ballistic pendulum derived and completed at the bottom of page 191 and solve for h. Use the Pythagorean theorem to find the horizontal leg of the triangle.

34. a) Use the moment of inertia of a cylinder on page 208
 b) Convert rpm to rev/s. Calculate the torque necessary to stop the cylinder and use that as your value for frictional torque. Now calculate the torque necessary to speed it up and add the frictional torque to it.

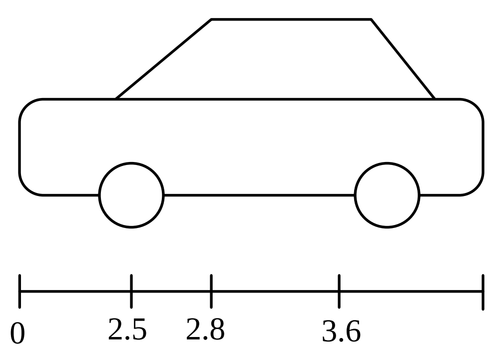
35. This is a two-things-stick-together problem. You know friction stopped the cars. Use energy equations (KE = work done by friction to stop the car) and solve for velocity. This will give the final velocity once the two cars stuck together. Now use the two-things-stick-together equation to calculate the initial velocity of the sports car. The SUV was not moving when it was hit.

36. Two bodies are being accelerated: the merry-go-round, which is a disk, and the two children, whose masses are concentrated at the outside edge of the disk. This causes them to behave rotationally, as a hoop. Sums of the moments of inertia times the angular acceleration = torque. To find the force, remember $\tau = Fxd$

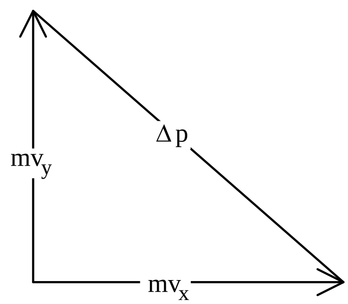
46. Use Equation 7-9a and Example 712 on page 183.

47. See equation 7-9a on page 183. Example problem 7-12 on page 183 is just like this problem also.

48. Use the illustration shown. Use Equation 7-9a and Example 712 on page 183.



62. This is a vector problem. The change in momentum = average force x time.
The change in momentum is the difference between the initial momentum horizontally, and the final momentum vertically. You'll have to subtract the two vectors.



The momentum horizontally went from mv_x to 0, and the momentum vertically went from 0 to mv_y To find v_y, use KE(initial) = PE(top) and solve for v_y. Use the Pythagorean Theorem to get Δp. Impulse force = Impulse x time. Convert milliseconds (ms) to seconds.

65. This is a "something blows up" problem. The astronaut and the space capsule are originally one mass, and become separate when he pushes off with his legs. We can assume the original mass (the astronaut and the space capsule) had no initial velocity. For part (a), just solve for v_2'. For part (B) solve for the impulse force.

70. This is a "two things stick together" problem, where the second object has no initial velocity. Find the velocity of the wood + bullet and use that as the initial velocity as it moves upward, stops and falls back down. You now have v_o, v and a. Choose from VAT, VAX or VATX and solve for distance.

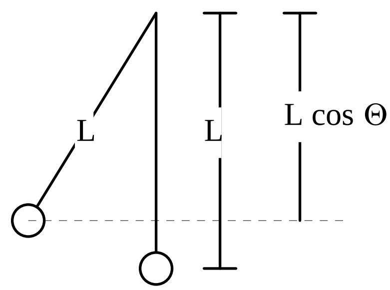
71. This is a "two things stick together" problem, where the second object has no initial velocity. To find the muzzle speed of the bullet (v_1) you need to find the speed (v_f) of the wood + bullet when the bullet embedded itself initially. The kinetic energy of the wood + bullet is absorbed by the work done by friction, so these two equations can be set equal to each other. Solve for v, use that for v_f in the momentum equation and solve for the initial velocity of the bullet.

73 a) This is a two-things-stick together problem. If we assume the meteor struck perpendicular to the Earth's orbital speed, we can take the initial velocity of the Earth to be 0. The recoil velocity will be the final velocity of the new Earth/meteor system.

b) The fraction = $\frac{\Delta KE_{Earth}}{\Delta KE_{Meteor}}$

c) ΔKE(Earth) = 1/2 $m_{Earth} v_f^2$

76. Find the height Ball A falls using trig. functions as shown:



a) Use energy equations to calculate the velocity of the ball A just before it hits ball B.
b) Use two-things-collide-elastically to find the velocity of each ball after the collision.
c) Use energy equations to calculate the maximum height again.

78. This problem will take several steps to solve.

i) At its maximum height, the skeet has no vertical velocity. Use the two-things-stick-together equation and the initially velocity of the pellet to find the initial velocity of the skeet/pellet system.
ii) Now you know the initial vertical velocity, the final vertical velocity (it stops) and acceleration. Find vertical distance.
iii) See problem #41 in chapter 2 for getting the time the skeet was in the air following its collision with the pellet. Since the horizontal velocity of the skeet has not changed, the horizontal distance it travels after being hit will just be the horizontal velocity times the time.
iv) Using the range equation, calculate the horizontal distance the skeet should have gone had it not been hit. Now you have enough information to calculate how much farther it traveled as a result of the collision with the pellet.