Engineering Dyanics
Homework 4 Notes

1.
You are obviously expected to determine the impulse. The impulse is the integral of *F dt*. This sounds tough until you realize that it is determined by the total equation, which is

$$mv_1 + \int Fdt = mv_2$$

The problem states that the block is stopped (velocity is zero) at the wall. You know the initial velocity. Use an energy equation to calculate the velocity just as the block gets to the wall.

2.
The golf ball is initially at rest (velocity is zero). Use projectile motion to determine the velocity just after impact. Plug this into the equation used in problem 1 above.

3.
The acceleration of the train is constant, so you should be able to use the equation describing the relationship between velocity and acceleration of $v = at$. Solve for a. The tension will be equal to the mass times the acceleration, $T = ma$. The locomotive wheel force is the acceleration of all of the cars and the locomotive. Don't forget to convert km/h to m/s correctly.

4.
Looks like a classic momentum problem, $m_1v_1 + m_2v_2 = (m_1+m_2)v_f$. (Those poor people in the car.)

5.
This problem has two parts that may be best solved using two techniques. I would be inclined to use an energy equation to determine the box's velocity at the bottom of the slide. The box slides on the cart using friction to accelerate the cart and decelerate the box until the box stops relative to the cart, meaning that both the box and the cart have the same velocity. The good news is that we can treat this as a momentum problem, where $m_{box}v_{box} + m_{cart}v_{cart} = (m_{box} + m_{cart})v_{both}$. The question of the time the box slides on the cart can be determined using the impulse equation where $mv_1 + \int Fdt = mv_2$. The force, F, is the frictional force, $mg\mu$, . If you use the box for the equation, substitute, and solve for time, t, you will get a negative value. This is because the impulse should have been subtracted (the velocity of the box *decreases*), not added, thus the term should have been negative to begin with.

6.
A classic momentum problem. Calculate the velocity of the skater just after he releases the block. This is described by the relationship $v_{B/m}$ which means the velocity of the block with respect to the man. This is described by $v_{B/m} = v_B - v_m$. If this seems confusing, try this: the velocity of the block with respect to the man is positive. We have reason to believe the velocity of the block will be positive (to the right), and the velocity of the man will be negative (to the left). By subtracting, we get the right sign.

Initially both velocities are zero, and then we have $m_B v_B + m_m v_m$ Solve for one of the two velocities using substitution of the relationship described above, then solve for the other velocity. Finally, use projectile motion to determine how long it will take for the block to hit the ice. Then apply that time, *t*, to determine how far the skater moved to the left, and the block to the right.

7.
First, remember that only the velocity perpendicular to the wall is affected by the impact and thus the coefficient of restitution. Calculate the velocity of ball *B* after the cue ball *A* impacts it using the coefficient of restitution, *e*. where $e = \frac{v_B' - v_A'}{v_A - v_B}$ .Now determine the velocity of ball *B* perpendicular to the cushion. (You will also need the velocity of ball *B* parallel to the cushion.) Using that value, calculate the velocity after the collision (perpendicular to the cushion) using the coefficient of restitution given. Use vector methods to combine the velocity of B parallel to the cushion and perpendicular to the cushion. The angle is a simple arctangent.

8.
The velocity of *A* along the *y*-axis does not change, so calculate and save for use later. Calculate the velocity of *A* along the *x*-axis. Using momentum, we know that

$m_A v_A = m_A v_A' + m_B v_B'$ (here v_A refers to the velocity of A along the y-axis).

Where $e = \frac{v_B' - v_A'}{v_A - v_B}$, solve for v_B'-v_A'. We now have two equations and two unknowns. When solving for the velocity of *A*, don't forget to recombine the components of the velocity of stone *A* using vector methods.

9.
Good news – no coefficients of restitution in this problem. Momentum is a vector operation: $m_1\bar{v}_1 + m_2\bar{v}_2 = m_1\bar{v}_1' + m_2\bar{v}_2'$. To solve this problem break it into two parts: puck *A* in the *x'* direction, puck *B* in the *x'* direction. Solve for that. Then puck *A* in the *y'* direction and puck *B* in the *y'* direction. Use the trig functions of the resulting velocities in the right side velocities. You should have two equations and two unknowns.

10.
We could look at this as angular impulse and momentum. Angular impulse is $\int M dt$ and as *rFt* (*rF* is a moment). For *F*, we use the horizontal component of the applied force. Angular momentum is described as *mvr*, so we can set up the equation as $\int M dt + rFt + mv_o r = mv_f r$. Solve for the final velocity. Note: you actually have to integrate with this problem.

11.
Note: what is displayed is on a smooth horizontal plane, not vertical. No gravity is involved. At point *B* there is obviously potential energy in the spring. At point *C* there is potential energy in the as well as kinetic energy giving the block a velocity. Knowing that

angular momentum is *mvr*, we might determine the angular momentum at point *C*, and then knowing that the radius, *r*, changed, we would determine the velocity knowing that the angular momentum remained constant.