PHYSICS 121 WORKSHEET 12 10/23/2017

NAME: SECTION:

1: Momentum Conservation, Impulse, and Work-Energy Theorem. Consider the astronaut of mass m_A, initially at rest, from Quiz 7 Question 1. In order to move toward the space station, she throws her wrench of mass m_W at speed v_W away from the station.

i) Write down the initial momentum $p_1 = p_{1A} + p_{1W}$ and the final momentum $p_2 = p_{2A} + p_{2W}$ of the astronaut-wrench system before and after the wrench is thrown. Are the two equal?

ii) What is the net impulse of the system $\Delta p = p_2 - p_1$? What is the impulse of the astronaut $\Delta p_A = p_{2A} - p_{1A}$ and of the wrench $\Delta p_W = p_{2W} - p_{1W}$?

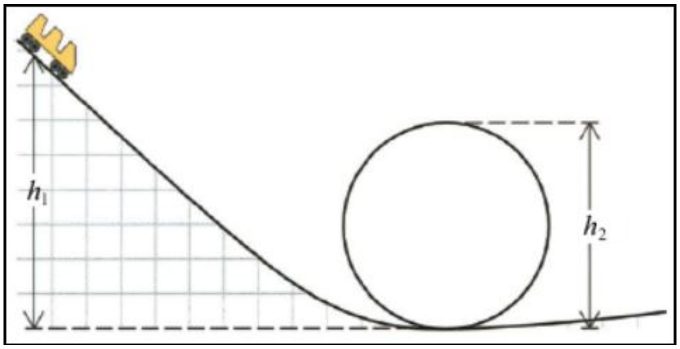
iii) Solve for the velocity of the astronaut v_A after she throws the wrench in terms of m_A, m_W, and v_W.

iv) What is the net kinetic energy of the astronaut-wrench system before and after the wrench is thrown? Are the two equal? Why or why not?

v) Is there any work done? If so, solve for it in terms of v_A, m_A, and m_B and identify what did the work. If not, why not?

vi) Pretend her throwing arm is also stuck to her suit by an elastic material with spring constant k. If the spring is initially unstretched, and she stretches it by a distance x in order to throw the wrench at the same speed v_W, what is the net work done?

2: Conservation of Energy. Consider the frictionless roller coaster ride shown below.



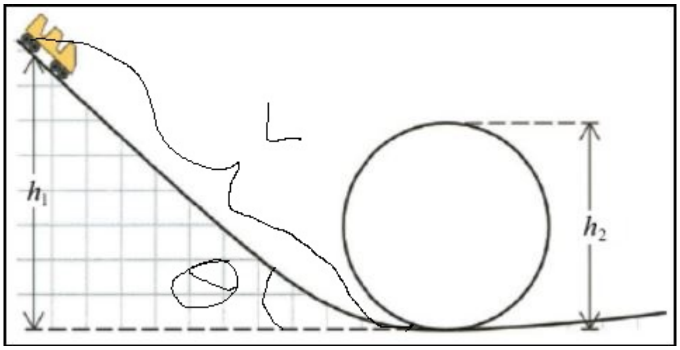
i) What is the total energy E_1 at point h_1 if the cart of mass m is initially at rest?

ii) At what speed v must the cart be moving at the top of the loop (point h_2) if it is to not fall down?

iii) What is the total energy E_2 at point h_2 if the cart is moving with the minimum velocity v found above, and if the loop is of radius R?

iv) Apply energy conservation (i.e, $E_1 = E_2$) to solve for h_2 in terms of h_1 and R.

3: Energy Dissipation Consider the same scenario as above but now let the roller coaster tracks have kinetic friction μ. Call the sloped region of the track length L and the angle this slope makes with the horizontal θ.



i) How much kinetic energy is lost by the time the roller coaster reaches the bottom of the slope? What is its velocity there?

ii) On the rise to the top of the circle, how much more kinetic energy is lost?

iii) What is the new total energy at the top of the loop? What is the difference from the frictionless case?

iv) What new initial velocity must the roller coaster have in order to supply the energy necessary to not fall off at the top of the loop?