Problem set 6

- Work-Energy theorem

In a new casino of Resort World, a supersized pinball machine Fig 6.1 is introduced. Resort World advertising boasts that a professional basketball player can lie on top of the machine and his head and feet will not hang off the edge!

The ball launcher in the machine sends metal balls up one side of the machine and then into play. The spring in the launcher has a force constant of 1.20 N/cm. The surface on which the ball moves in inclined ϑ = 10.0° with respect to the horizontal. The spring is initially compressed its maximum distance d = 5.00 cm. A ball of mass 100 g is projected into play by releasing the plunger. As a visitor of this new Casino, do you find the play of the giant machine exciting? *(Hint: Draw the ball-spring diagram and find the maximum distance that the ball travels up.)*

- Isolated system (Energy)

The system show in Figure 6.2 consists of a light, inextensible cord, light, frictionless pulleys, and blocks of equal mass. Notice that block B is attached to one of the pulleys. The system is initially held at rest so that the blocks are at the same height above the ground. The blocks are then release. Find the speed of the block A at the moment the vertical separation of the block is h. *(Hint, set up the initial and final positions for the two blocks.)*

Figure 6.1

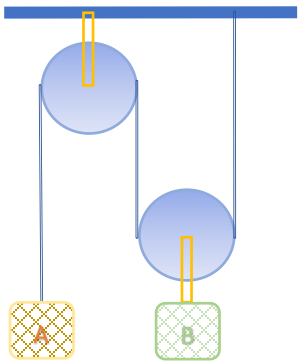

Figure 6.2

- Power

Duffy got his driver's license last Wednesday. As he steps on the gas pedal, a car accelerates from rest. During the first few seconds of motion, the car's acceleration increases with time according to the expression: $a = 1.16t - 0.210t^2 + 0.240t^3$. Duffy and his car's total mass is 1160 kg.

a) What is the change in kinetic energy of the car during the interval from t = 0 to t = 2.50 s?
b) What is the minimum average power output of the engine over this time interval?
c) Why is the value in part b) described as the minimum value?

- Change in mechanical energy for non-conservative forces

This problem is a good review of fundamental concepts. We will NOT discuss this one step by step in our classroom. We will check everyone's answers.

Lucy of mass m starts from rest and slides without friction from a height h along a slide next to a pool in Water Country shown Fig 6.3. She is launched from a height h/5 into the air over the pool. We wish to find the maximum height she reaches above the water in her projectile motion.

a) Is the Lucy-Earth system isolated or non-isolated? Why?
b) Is there a nonconservative force acting within the system?
c) Define the configuration of the system when Lucy is at the water level as having zero gravitational potential energy. Express the total energy of the system when the child is at the top of the waterslide.
d) Express the total energy of the system when Lucy is at the launching point.
e) Express the total energy of the system when Lucy is at the highest point in her projectile motion.
f) From parts c) and d), determine her initial speed v, at the launch point in terms of g and h.
g) From parts d), e) and f), determine her maximum airborne height y_{max} in terms of h and the launch angle θ .
h) Would your answers be the same if the waterslide were not frictionless? Explain.

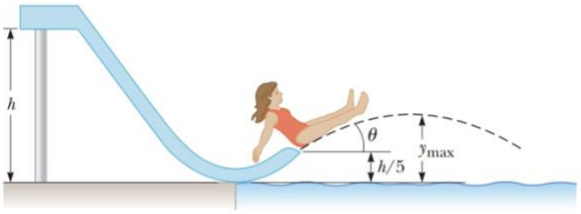

Figure 6.3

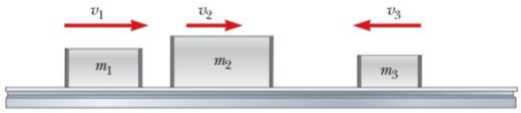

Figure 6.4

- Non-isolated system (Momentum)

Three carts of different masses ($m_1 = 4.00kg, m_2 = 10.0kg,\ m_3 = 3.00kg$)move on a frictionless horizontal track shown in Fig 6.4 ($v_1 = 5.00\frac{m}{s}, v_2 = 3.00\frac{m}{s}, v_3 = 4.00\frac{m}{s}$). Velcro couplers make the carts stick together after colliding.

a) Find the final velocity of the train of three carts.
b) Does your answer in part a) require that all the carts collide and stick together at the same moment? What if they collide in a different order?

- Collisions in two dimensions

Two particles with masses m and 3m are moving toward each other along the x axis with the same initial speeds v_i. Particle m is traveling to the left, and particle 3m is traveling to the right. They undergo an elastic glancing collision such that particle m is moving in the negative y direction after the collision at a right angle from its initial direction.

a) Find the final speeds of the two particles in terms of v_i.
b) What is the angle θ at which the particle 3m is scattered?