Part I

1. Consider two blocks stacked one above the other on a table. Someone pulls the bottom block to the right with a rope in such a way that both blocks accelerate to the right but no slipping occurs at the interface between the top and bottom blocks. Friction at the interface between the two blocks does

   (a) no work on the top block

   (b) positive work on the top block.

   (c) negative work on the top block

   (d) first positive then negative work on the top block.

   Answer: (b) The displacement is in the same direction as the force of friction.

2. A force of 10 N is applied to a 2.0 kg mass at rest on which the force of friction is 4.0 N. The net work done on the mass after two seconds will be:

   (a) 36 J (b) 60 J (c) 72 J (d) 100 J

   Answer: (a) A mixture of kinematics and energetics. First acceleration = Fnet/m=3 m/s^2 so $v = at = 6$ m/s But $W = \Delta KE = \frac{1}{2}mv^2 - 0 = 36J$

3. A cart on an air track is moving at 0.5 m/s when the air is suddenly turned off so that friction between the cart and the track now acts. The cart comes to rest after traveling 1 m. The experiment is repeated, but now the cart is moving at 1 m/s when the air is turned off. How far does the cart travel before coming to rest?

   (a) 1 m (b) 2 m (c) 3 m (d) 4 m

   Answer: (d) $\frac{1}{2}mv^2 = f\Delta x$ so if velocity is doubled then distance traveled will be four times as great.

4. Compared to the amount of energy required to accelerate a car from rest to 10 miles per hour, the amount of energy required to accelerate the same car from 10 mph to 20 mph is

   (a) the same. (b) twice as much. (c)three times as much. (d) four times as much.

   Answer (c) To go from 0 to 20 mph requires 4 times as much energy as from 0 to 10 mph. So it require 3 times as much energy to go from 10 to 20 mph than from 0 to 10 mph

5. A crate is moving to the right on a conveyor belt without slipping. The conveyor belt maintains a constant speed. The net work done on the crate is

   (a) positive

   (b) negative

   (c) zero

   (d) first to the right then to the left.

   Answer (c): Constant speed means the net force on the crate is zero so the net work done is zero.

Part II

1. A force of 120 N is used to lift a 10 kg box to a height of 5.0 m.

   (a) What work was done by the applied force?
   $W = F\Delta x = 120 \times 5 = 600$ J

   (b) What is the net force acting on the box?
   $F_{\text{net}} = F - w = 120 - mg = 120 - 98 = 22$ N

   (c) If the box started from rest what is the kinetic energy of the box by the time it reaches a height of 5.0 m?
   $\Delta KE = W_{\text{net}} = F_{\text{net}}\Delta x = 22 \times 5 = 110$ J

2. When a 50 kg person is hangs from a 20 m bungee cord it stretches to a length of 32 m.

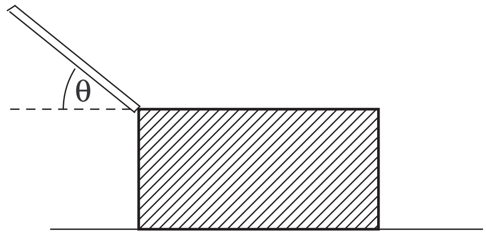
   (a) Find the spring constant of the bungee cord, assuming it obeys Hooke's law.
   According to Hooke's Law $F = kx \quad \Rightarrow \quad k = F/x$, where x is the extension of the cord, which in this case is 12 m, and F in this case is the weight of the person which is $(50)(9.8) = 490$ N. Hence $k = 490/12 = 40.8$ N/m.

   (b) How much work is required to stretch the cord by this much?
   $W_s = \frac{1}{2}kx^2 = \frac{1}{2}(40.8)(12)^2 = 2940$ J.

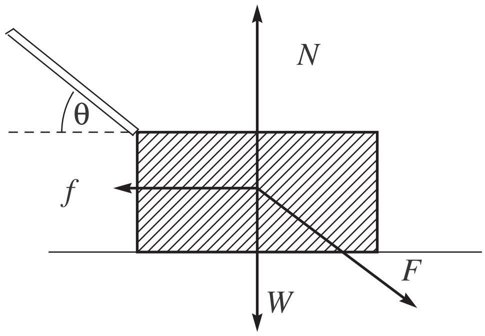
   (c) How heavy a person is required to make the cord stretch twice as much?
   Since Hooke's Law is a linear law it follows that double the force is required for double the extension. Therefore a 100 kg person is needed.

   (d) How much additional work is required to make the cord stretch twice as much?
   Since the extension is double and the work is proportional to the square of the extension then the work required is 4 times as great. Which means $4 \times 2940 = 11760$ J is needed. Since we are asked for *additional* work we must have $11760 - 2940 = 7820$ J more.

3. A block of weight $W = 20$ N is pushed with a force $F = 30$ N through a horizontal distance of 5 m using a stick which is at an angle of $\theta = 37^o$ above the horizontal as shown. The coefficient of kinetic friction between the table and the block is $\mu = 0.25$.



(a) Draw a free body diagram showing all the forces acting on the block.



(b) Calculate the value of the normal force and the frictional force between the block and the table.

The normal force balances the weight W and the vertical component of the downward force F_y. $N = W + F_y = 20 + 30 \sin 37 = 38.1$ N. Now since the frictional force $f_k = \mu_k N$ we have $f_k = (0.25)(38.1) = 9.5$ N

(c) Find the acceleration of the block.

The acceleration is to the right and $a = F_{\text{net}}/m$ were $m = W/g = 20/9.8 = 2.04$ kg and $F_{\text{net}} = F_x - f_k$. $F_x = 30 \cos(37) = 24.0$ N so $F_{\text{net}} = 24.0 - 9.5 = 14.5$ N. So $a = 14.5/2.04 = 7.1$ m/s^2

(d) Find the work done by each of the forces acting on the block and hence find the net work done on the block.

The normal force and weight do no work as they act perpendicular to the displacement. The force F does work $W_F = F_x \Delta x = 24 \times 5 = 120$ J. The frictional force does negative work $W_{f_k} = -9.5 \times 5 = -47.5$ J. So the net work done is $120 - 47.5 = 72.5$ J.

(e) The stick is removed after the block has traveled 5 m, and the block slides to rest under friction. How far does it travel until coming to a rest?

The energy gain must be lost due to friction. Suppose the distance traveled before the block slides to rest is d. Then $f_k d = 72.5 \quad \Rightarrow \quad d = 72.5/f_k =$. Now, since we are no longer pushing down the Normal force is 20 N and hence $f_k = 0.025(20) = 5$ N. Therefore, $d = 72.5/5 = 14.5$ m