Answers to Work, Energy and Power Problems

1. C The formula for kinetic energy is:

$$K = \frac{1}{2}mv^2$$

The kinetic energy is inherently determined by the speed and mass of the object. This quantity is equal to the work which would be required to bring the body to rest. The kinetic energy does not depend upon the force acting upon the object in a given instant of time.

2. D Both A and C are correct. A centripetal force performs no work on an object undergoing uniform circular motion because the force in this case is always perpendicular to the displacement. The kinetic energy of the object remains constant, i.e. zero change.

3. D The work performed in lifting the car = $W = Fd\cos\theta$ = 10,000 N X 10 m = 100,000 J. There is very little work performed in moving the car horizontally because the main force is exerted upwards by the crane while the displacement is horizontal.

4. A The amount of work performed by the combustion of the jet-fuel would be greater to accelerate at the higher speed. The amount of work in this case equals the change in kinetic energy, and kinetic energy varies with the square of the speed as:

$$K = \frac{1}{2}mv^2$$

So changes in the magnitude of velocity require more work at higher magnitudes. Another possible way to think about it is to remember that work requires the force operating over a distance while a change in velocity requires an acceleration (a force) over a certain duration of time. Because at higher speeds, the airplane will be covering more distance in a given amount of time, for the same acceleration more work is necessary.

5. B Mechanical energy is conserved in a system if the only force that does work is a conservative force. With the pendulum, this force is gravity.

6. A Because the force operating the pulley system undergoes twice the displacement of the weight, in performing the work needed to lift the weight, a force of only half the weight is required on the rope.

7. B Work can be defined for friction forces. The force of friction between two objects in relative motion performs an amount of work equal to the magnitude of the friction force times the displacement.

8. C Power is the rate at which work is performed.

$$\bar{P} = \frac{\Delta W}{\Delta t}$$

Because we know the duration of the event, we need to know the total amount of work performed by the friction force. Note that the potential energy is being converted into kinetic energy and the heat of friction. The initial potential energy is expressed:

$$U_g = mgy$$

For the man upon the rock face, this value is 10,000 J. His kinetic energy at the bottom can be determined using:

$$K = \frac{1}{2}mv^2$$

This value is 5000 J. The difference between the potential energy at the top and the kinetic energy at the bottom equals the energy dissipated by the friction force, 5000 J. Friction performs this work in four seconds, so the average power over the interval is 1250 W.