PHYSICS 1020

Homework set 6

29 January 1997

[**6.3**] In order for you to get out of bed with the least amount of work, would it be better for your bed to be on the floor or about a meter high? Explain.
Answer:
The center of gravity of an average adult human in a standing position is about one meter above ground. Therefore having a bed one meter high would allow you to get up without lifting your center of gravity, thus very little work would be necessary to get up.

[**6.5**] Making estimates: About how much work would it take to lift the U.S. population by 1 km?
Answer:
The US population is about 250 millions $= 2.5 \times 10^8$. Assuming an average mass of about 50 kg, i.e. a weight of about 500 N per person, the total weight is $= 500 \times 2.5 \times 10^8 = 1.25 \times 10^{11}$ N. The work necessary to lift this weight by 1 km = 1000 m equals 1.25×10^{14} J.

[**6.7**] Name the type of energy possessed by each of the following: Jill at rest at the top of a sliding board, Jill sliding off the bottom of the sliding board, dynamite, sunlight, coal, hot air.
Answer:
Jill on top of the sliding board: gravitational potential energy;
Jil sliding off the bottom of the board: kinetic energy;
dynamite: chemical energy;
sunlight: radiant energy;
coal: chemical energy;
hot air: thermal energy
(plus possibly gravitational and kinetic energy, depending on its position and state of motion).

[**6.10**] If you triple your height above ground, how is your gravitational energy (relative to the ground) affected? What if you halve your height?
Answer:
The gravitational potential energy with respect to the ground is $= mgh$, where $h =$ the height above ground. Thus tripling the height will triple the gravitational energy, and halving the height will halve it.

[**6.15**] You throw a baseball horizontally, and Jill catches it. Describe the energy transformation that occurs (a) during the throw (while the ball is in your hand) and (b) during the catch. (Neglect air resistance)
Answer:
(a) while the ball is in your hand, chemical energy from your body is converted into kinetic energy;
(b) during the catch, chemical energy from Jill's body is used to slow down the ball. The kinetic energy of the ball and the chemical energy from Jill's body are converted into thermal energy of the ball, the mitt, and Jill's hand.

[**6.16**] You throw a ball upward and then catch it at the same height. How does the ball's final speed compare with its initial speed (a) neglecting air resistance and (b) including air resistance? Defend your answers.

Answer:

(a) If air resistance can be neglected, energy conservation implies that the final velocity of the ball is the same as its initial velocity; what happens is that during the upward motion of the ball, the kinetic energy is completely converted into gravitational potential energy, and during the downward motion the gravitational energy is converted back into kinetic energy. If there is no loss of mechanical energy (no air resistance), the final kinetic energy is the same as the initial one, and therefore the speeds are the same.

(b) If there is air resistance, some of the kinetic energy is converted into thermal energy, and the final speed is smaller than the initial speed.

[**6.27**] Which process has the larger power output: 2 J of work performed in 0.1 s or 1000 J of work performed in an hour?

Answer:

Power is work per unit time: 2 J in 0.1 s equals $2/0.1 = 20$ W;
1000 J in one hour = $1000/3600$ W = about 0.27 W;
this is a smaller power than that for the 2 J process.

[**6.28**] A drive force of 500 N acts on an automobile while it travels 60 km.

(a) How much work did the drive force do on the automobile?

(b) If the trip took 50 minutes, what was the automobile's average power output in watts?

(c) If the auto's energy efficiency is 10 %, what was its power input (its rate of converting the gasoline's chemical energy into other forms) in watts? How many 100 W lightbubs could this light up?

Answer:

(a) The total work done = force times distance = 500 N times 60 km = 30 MJ;

(b) 50 minutes = 3000 seconds; 30 MJ/3000 seconds = 10 kW

(c) efficiency = 10% $\Rightarrow$ the total power input = 10 times the power output = 100 kW, which could light up 1000 lightbulbs of 100 W each.