Giancoli 6th Edition Problem Solutions Chapter #6

- **Problem #3**

QUESTION: A 1300 Nt crate rests on the floor. How much work is required to move it at constant speed

(a) 4.0 m along the floor against a friction force of 230 Nt, and (b) 4.0 m vertically?

ANSWER: (a) The work against friction is Work = 230 Nt × 4.0 m = 920 Joules

```
230 * 4.0
```

```
920.
```

(b) The work against gravity is W = mgh = $\frac{1300\text{ Nt}}{9.8\, m/\text{sec}^2} \times 9.8\, m/\text{sec}^2 \times 4.0$ m = 5,200 Joules

```
1300. * 4.0
```

```
5200.
```

- **Problem #5**

QUESTION: A box of mass 5.0 kg is accelerated from rest across a floor at a rate of 2.0 m/sec^2 for 7.0 sec. Find the net work done on the box.

ANSWER: Recall the definition of acceleration $a = (V_f - V_0)/t$ can be rewritten as $V_f = V_0 + a\,t$. We know V_0=0 since the box started at rest and the acceleration is a =2.0 m/s^2 for a time t=7.0 sec. So we obtain V_f=14 m/s.

```
V0 = 0.;
a = 2.0;
t = 7.0;
Vf = V0 + a * t
```

```
14.
```

The change in kinetic energy is by definition ΔKE = KE_f-KE_0 where $KE_0 = \frac{1}{2} m V_0^2 = 0$ since V_0=0 m/sec. The initial $KE_0 = \frac{1}{2} m v_0^2 = 0$ Joules and the final $KE_f = \frac{1}{2} m v_f^2 = 490$ Joules so ΔKE = KE_f-KE_0=(490 J - 0 J)= 490 J. The work-kinetic energy theorem says W=ΔKE=490 Joules in this case.

```
m = 5.0;
V0 = 0.;
KE0 = (1 / 2) * m * (V0)^2
```

```
0.
```

```
Vf = 14.0;
KEf = (1 / 2) * m * (Vf)^2
```

```
490.
```

```
W = KEf - KE0
```

```
490.
```

- **Problem #12**

The force on an object acting along the x axis varies as shown in Fig 6-37. Determine the work done by this force to move the object (a) from x=0 to x=10m and (b) from x=0 to x=15 m.

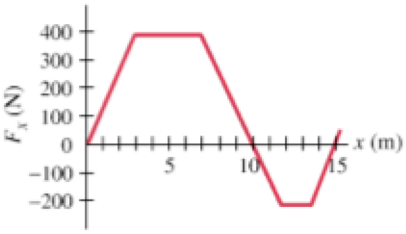

FIGURE 6–37
Problem 12.

PART A: The work from x=0 to x=10 m consists of three pieces: $W_1 = \frac{1}{2} * 3\, m * 400.\,\text{Nt} = 600\, J$. This work was computed even though the force is not constant. The basic idea is that work is the area between the graph of the function for the force and the x-axis. This area is the triangle region in the graph below marked by W_1. The area of this triangle is $W_1 = \frac{1}{2} \times 3\, m \times 400\,\text{Nt} = 600\, J$ since the area of a triangle is $\frac{1}{2}$ base × height and the Joule = J = Nt.-m. The next bit of work from x=3m to x=7m is with a constant force =400 Nt. so the work done is given by the formula for a rectangle area, that is $W_2 = (7\, m - 3\, m) \times 400\,\text{Nt} = 1600\, J$. The work done from x=7m to x=10m is the area of the triangle given by $W_3 = \frac{1}{2} \times (10\, m - 7\, m) \times 400\,\text{Nt} = 600\, J$. The net work or total work W_{Total} in going from x=0m to x=10 m is equal to $W_{\text{Total}} = W_1 + W_2 + W_3$=600 J + 1600 J + 600 J = 2800 J.

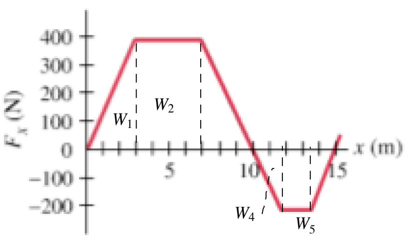

FIGURE 6–37
Problem 12.

PART B: The work done from x=0 m to x=15 m includes the work calculated in PART A but additionally the work from x=10 m to x=15m must be included as well. The work done W_4 from x=10m to x=12m is the area of a triangle and this work is considered negative since the force is negative so $W_4 = \frac{1}{2} \times (12\, m - 10\, m) \times (-200\,\text{Nt}) = -200\, J$. The next bit of work is represented by a rectangle and the value is $W_5 = (13.5\, m - 12\, m) \times (-200\,\text{Nt}) = -300\, J$ and finally $W_6 = \frac{1}{2} \times (15\, m - 13.5\, m) \times (-200\,\text{Nt}) = -150\, J$. The total work from x=10 m to x=15m is thus $W_{\text{Total}} = W_1 + W_2 + W_3 + W_4 + W_5 + W_6$= 2800 J - 200 J-300J-150 J=2800J-650J=2150J.

- **Problem #15**

QUESTION: At room temperature, an oxygen molecule with a mass of 5.31×10^{-26} kg typically has a kinetic energy KE of about 6.21×10^{-21} J . How fast is the oxygen molecule moving?

ANSWER: $\text{KE} = \frac{1}{2}\,\text{mV}^2$ so solving for the velocity $V = \sqrt{2 \times \text{KE}/m}$ = 484 m/sec since substitution yields

$$m = 5.31 * 10^{-26};\ KE = 6.21 * 10^{-21};\ V = \sqrt{2 * KE / m}$$

```
483.63
```

- **Problem #16**

QUESTION-PART A: If the KE of an arrow is doubled, by what factor has the speed increased?

ANSWER: $\text{KE}_f = 2\,\text{KE}_0$ where $\text{KE}_0 = \frac{1}{2}\, m\, V_0^2$ is the initial kinetic energy while $\text{KE}_f = \frac{1}{2}\, m\, V_f^2$ is the final kinetic energy. Substitution yields $\frac{1}{2}\, m\, V_f^2 = \text{KE}_f = 2\,\text{KE}_0 = 2(\frac{1}{2}\, m\, V_0^2) = m\, V_0^2$ so in the end $\frac{1}{2}\, m\, V_f^2 = m\, V_0^2$ or $V_f^2 = 2\, V_0^2$ and thus

$V_f = \sqrt{2}\, V_0$. Since $\sqrt{2}$ =1.4 approximately the final velocity is 1.4 times the initial velocity $V_f = 1.4\, V_0$.

```
√2.
1.41421
```

QUESTION B: If the arrow's speed is doubled by what factor is the kinetic energy KE increased? We still have the definitions of $KE_0 = \frac{1}{2} m V_0^2$ is the initial kinetic energy while $KE_f = \frac{1}{2} m V_f^2$ is the final kinetic energy. In this case the velocity has been doubled $V_f = 2 V_0$ so the final kinetic energy is equal to $KE_f = \frac{1}{2} m V_f^2 = \frac{1}{2} m (2 V_0)^2 = 4 \times (\frac{1}{2} m V_0^2) = 4 KE_0$. So doubling the velocity increases the kinetic energy by 4 times.

- **Problem #17**

QEUSTION: How much work is required to stop an electron that has a mass $m = 9.11 \times 10^{-31}$ kg and is moving with a speed 1.90×10^6 of m/s?
ANSWER: The Work-Kinetic Energy Theorem says that $Work = KE_f - KE_0$. The final kinetic energy is zero since the electron is brought to rest so $V_f = 0$ and $KE_f = \frac{1}{2} m V_f^2 = 0$. The initial kinetic energy is $KE_0 = \frac{1}{2} m V_0^2 = \frac{1}{2} \left(9.11 \times 10^{-31} \text{ kg}\right) \left(1.90 \times 10^6 \, m/s\right)^2 = 1.6 \times 10^{-18} \, J$. The work done is $W = 0 - 1.6 \times 10^{-18} \, J = -1.6 \times 10^{-18} \, J$. The negative sign means work is done on the electron to bring it to rest.

```
m = 9.11 * 10^-31;
V0 = 1.9 * 10^6;
KE0 = 1/2 * m * V0^2
1.64436 × 10^-18
```

- **Problem #18**

QUESTION: How much work must be done to stop a m=1250 kg car traveling at $V_0 = 105$ km/h and $V_f = 0$?
ANSWER: The initial kinetic energy is $KE_0 = \frac{1}{2} m V_0^2 = \frac{1}{2}\, 1250 \text{ kg} \times (105 \text{ km/hr} \times 1000 \, m/\text{km} \times \text{hr}/60 \, m \times \text{min}/60 \text{ sec})^2 = 5.3 \times 10^5 \text{ J}$.
The work done to stop the car is $W = KE_f - KE_0 = -5.3 \times 10^5$ J and the minus sign means work was done on the car.

```
m = 1250.;
V0 = 105 * 1000. / (60 * 60);
KE0 = 1/2 * m * V0^2
531 684.
```

- **Problem #24**

QUESTION: How high will a 1.85 kg rock go if thrown straight up by someone who does 80.0 J of work on it? Neglect air resistance.
SOLUTION: Work=80.0 Joules and Work=ΔPE=mgh=1.85 kg ×9.8 m/sec^2 × h. Solving for h yields

$$h = \frac{\text{Work}}{\text{mg}} = \frac{80.0 \, J}{1.85 \text{ kg} \times 9.8 \, m/\text{sec}^2} = 4.4 \text{ m}$$

```
Work = 80.0;
m = 1.85;
g = 9.8;
h = Work / (m * g)
4.41258
```

- **Problem #27**

QUESTION: A 7.0 kg monkey swings from one branch to another 1.2 m higher. What is the change in potential energy?

ANSWER: ΔPE=mgh=7.0 kg × 9.8 m/sec^2 × 1.2 m = 82.3 Joules

```
m = 7.0;
g = 9.8;
h = 1.2;
ΔPE = m * g * h
```

```
82.32
```

- **Problem #34**

QUESTION: A novice skier, starting from rest, slides down a frictionless 35° incline whose vertical height is 185 m. How fast is she going when she reaches the bottom?

AMSWER: ΔPE=mgh and ΔPE=KE$_f = \frac{1}{2} m V^2$ so mgh=$\frac{1}{2}$ m V^2. Cancellation of m and solving for V=$\sqrt{2 g h}$ = 60.2 m/sec.

```
g = 9.8;
h = 185.;
V = √(2 * g * h)
```

```
60.2163
```

- **Problem #43**

QUESTION:The roller-coastercar shown in Fig (6-4) below

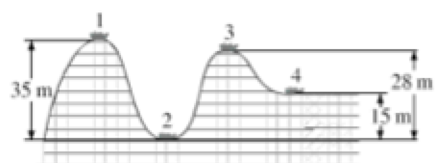

FIGURE 6–41 Problems 43 and 53.

The roller coaster is dragged up to point 1 where it is released from rest. Assuming no friction, calculate the speed at points 2, 3, and 4.
ANSWER: The speed at a given point is obtained from conservation of energy. The Kinetic Energy KE at a point in the diagram above equals the difference in Potential Energy ΔPE=mgΔh where Δh is the difference in height between point 1 and one of the other points.

SPEED AT POINT 2: $\frac{1}{2} m V_2^2$ = mgΔh where Δh=35m so $V_2 = \sqrt{2 g\Delta h}$ = 26.2 m/sec.

```
g = 9.8;
Δh = 35.;
V2 = √(2 * g * Δh)
```

```
26.1916
```

SPEED AT POINT 3: $\frac{1}{2} m V_3^2$ = mgΔh where Δh=(35m-28m) so $V_3 = \sqrt{2 g\Delta h}$ = 11.7 m/sec.

```
g = 9.8;
Δh = 35. - 28.;
V3 = √(2 * g * Δh)
```

```
11.7132
```

SPEED AT POINT 4: $\frac{1}{2} m V_4^2$ = mgΔh where Δh=(35m-15 m) so $V_4 = \sqrt{2 g\Delta h}$ = 19.8 m/sec.

```
g = 9.8;
Δh = 35. - 15.;
V4 = Sqrt[2 * g * Δh]
```

19.799

Problem # 47

QUESTION: Two railroad cars, each of mass 7650 kg and traveling 95 km/h in opposite directions, collide head-on and come to rest. How much thermal energy is produced in this collision?

ANSWER: Conservation of energy applied in this case yields $KE_1 + KE_2$ = ThermalEnergy. $KE_1 = \frac{1}{2} m V_1^2$ is the kinetic energy of train #1 and similarly for train #2. Thus Thermal Energy = $\frac{1}{2} m V_1^2 + \frac{1}{2} m V_2^2 = 2(\frac{1}{2} m V_1^2)$ since $V_1 = V_2$. The thermal energy released is 5.3×10^6 Joules.

```
V1 = 95 * 1000 / (60 * 60.);
m = 7650;
ThermalEnergy = 2 * (1/2 * m * V1^2)
```

5.32726×10^6

Problem #50

A 145-g baseball is dropped from a tree 13.0 m above the ground.
PART A: With what speed would it hit the ground if air resistance could be ignored?
ANSWER: ΔPE=KE where ΔPE=mgh with m=0.145 kg and h=13 m and KE = $\frac{1}{2} m V^2$. Thus $\frac{1}{2} m V^2$ = mgh and thus V=$\sqrt{2 g h}$ =16 m/s

```
m = 145 / 1000.;
g = 9.8;
h = 13.0;
V = Sqrt[2 * g * h]
```

15.9625

PART B: If it actually hits the ground with a speed of 8.00 m/s, what is the average force of air resistance exerted on the baseball?
ANSWER: ΔPE=KE+ W where W=work against air resistance. W=Fh where F=average force of air resistance. Combining
mgh=$\frac{1}{2} m V^2$+Fh. Solving for F we get F = (mgh - $\frac{1}{2} m V^2$)/h = 1.06 Nt is the average force of air resistance.

```
m = 145 / 1000.;
h = 13.0;
V = 8.0;
g = 9.8;
F = (m * g * h - (1 / 2) * m * V^2) / h
```

1.06408

Problem #58

How long will it take a 1750-W motor to lift a 315 kg piano to a sixth-story window 16.0 m above? The rate that the motor uses energy is Power=Energy/Time = 1750-Watts where a Watt=Joule/second. The work done by the motor in a time T is W = P×T and that work goes into increasing the potential energy PE of the piano. So PT=mgh and solving for the time T = mgh/P = 28.2 seconds.

```
m = 315.;
g = 9.8;
h = 16.0;
P = 1750;
T = m * g * h / P
```

```
28.224
```

- **Problem #62**

Electrical Energy units are often expressed in the form of "kilowatt-hours."

PART A: Show that one kilowatt-hour (kWh) is equal to 3.6×10^6 Joules.

ANSWER:

$$1 \text{ kilowatt-hour} = 1000 \text{ watt-hour} * \frac{60 \text{ minutes}}{1 \text{ hour}} * \frac{60 \text{ seconds}}{\text{minutes}} * \frac{\text{Joule}}{\text{Watt-hour}} = 3.6\times10^6 \text{ Joules}$$

```
1000. * 60. * 60.
```

3.6×10^6

PART B: If a typical family of four uses electric energy at an average rate of 520 Watts, how many kWh would their electric bill be for one month?

ANSWER: Basically P=520 watts multiplied by the time in hours in a month yields the total energy used so

Total Energy Used in One Month = 520 Watts * 30 days $*\frac{24 \text{ hours}}{\text{day}}$/day * $\frac{\text{kilowatt}}{1000 \text{ watt}}$=374 KWh where KWh=KiloWattHour

```
520 * 30 * 24 / 1000.
```

```
374.4
```

PART C: How many joules would this be? From PART A we got one kilowatt-hour (kWh) is equal to 3.6×10^6 Joules. So for this problem the energy used is calculated

$$374 \text{ KiloWatt} \times \text{Hour} * \frac{3.6\times10^6 \text{ Joules}}{\text{KiloWatt}} = 1.35 \times 10^9 \text{ Joules}$$

```
374 * 3.6 * 10^6
```

1.3464×10^9

PART D: Suppose their energy company charges $0.12 per KiloWattHours, then what is their energy bill each month?

374 KWh * $0.12/KWh = $44.9 per month. Their monthly bill depends on the total energy used each month and indirectly on the rate of energy use.

```
374 * 0.12
```

```
44.88
```