107 Answer Key - Chapters 5 & 6 assignments

Conceptual: Ch.5: 22, Ch.6:18

Problems: Ch5.: 2, 4, Ch.6: 2, 6

September 30, 2005

1 Chapter 5

1.1 Conceptual Exercises

22) "If gold were always sold by weight, could you make money buying gold at one altitude above the ground and selling at a different altitude? Where would you want to buy - at a high altitude or a low altitude?"

We learned in Chapter 5 that the force due to gravity isn't really constant, but decreases with distance from the surface of the Earth. Since the weight of gold is just the force from gravity on gold, we would want to $\boxed{\text{buy at a higher altitude}}$ (where the weight is less, so we pay less), and $\boxed{\text{sell at a lower altitude}}$ (where the weight is more, so others pay more).

1.2 Problems

2) "Find the change in the gravitational force between two planets when the distance between them is increased to three times its previous value."

Newton's Law of Gravity says that the force of gravity between two objects with masses m_1 and m_2 separated by a distance d is:

$$F_g = 6.67 * 10^{-11} \frac{m_1 * m_2}{d^2}. \tag{1}$$

If we triple the distance $d \rightarrow 3d$, then $d^2 \rightarrow (3d)^2 = 9 * d^2$. The effect on our gravitational force is:

$$F_g \rightarrow \frac{1}{9} F_g = 6.67 * 10^{-11} \frac{m_1 * m_2}{9d^2}. \tag{2}$$

Thus, the new gravitational force is $\boxed{\text{1/9th the original size.}}$

4) "The moon's mass is $7.4 * 10^{22}$kg, and its radius is $1.7 * 10^6$m. Use Newton's law of gravity to find the weight of a 1 kg object lying on the moon's surface."

We need to plug our masses, $m_1 = 7.4 * 10^{22}$kg and $m_2 = 1$kg, and our distance of separation, $d = 6.4 * 10^6$m, into Newton's Law of Gravity, Eq. 1 above. Doing this, we get:

$$Weight = 6.67 * 10^{-11} \frac{7.4 * 10^{22} kg * 1kg}{(6.4 * 10^6)^2} = 17.07 * 10^{-1} N = \boxed{1.7\text{N}}. \tag{3}$$

2 Chapter 6

2.1 Conceptual Exercises

18) a) "Where would an apple have greater gravitational energy, at 100 km high or at 1000 km high?"

Our definition of gravitational energy is Grav E = (weight)*(height). Near the surface of the earth the weight will not change much with height, so we expect that the $\boxed{\text{gravitational energy will be greater at 1000 km high.}}$

b) "Would the gravitational energy of an orbiting satellite be increased or decreased by moving it from an orbit that is 6000 km high up to an orbit that is 12,000 km high?"

The satellite is pretty high up, so it's not safe to assume the weight is constant. But it still has weight at any altitude between 6000 km and 12,000 km, even though it's getting smaller. So we're still doing work, Work = (Force)*(distance), and the force is nonzero. So even though the amount of work we need to do to go a bit higher keeps getting less and less, we still keep doing positive work going to higher altitudes, so overall we have to do work to go from 6000 km to 12,000 km, and since we did positive work, the satellite must now have more energy (at 12,000 km).

c) "At which point, 6000 km high or 12,000 km high, does a satellite have the larger gravitational force on it?"

As we saw in part b), the gravitational force decreases with distance, so $\boxed{\text{the gravitational force is larger at 6000 km.}}$

2.2 Problems

2) "A jumbo jet has four engines, each having a thrust of 30,000 N. How much work do the engines do during a 1500 m takeoff run?"

We know Work = (Force)*(distance). Each engine supplies 30,000 N of force, so the total force applied is 30,000 N *4 = 120,000 N. Applied over 1500 m, the total work done by all the engines is $\boxed{120,000N * 1500m = 180000000 = 1.8 * 10^8 J.}$

6) "You slam on your automobile brakes, sliding a certain distance with locked brakes. How much further would you slide if you had been moving half as fast?"

Intuition suggests that we won't slide further, but rather not quite as far. As we slide to a stop, the force of friction does work on the car - let's assume that the force of friction is constant for all speeds (do you agree with this assumption?). Then the work done as we slide is $Work = F_{friction} * dist$. This work changes our kinetic energy from its initial value of $\frac{1}{2}(mass) * (speed)^2$ to zero. Thus, by the work-energy principle:

$$Work = F_{friction} * dist = Change\ in\ kinetic\ energy = \frac{1}{2}(mass) * (speed)^2. \tag{4}$$

If we halve the speed, we need to multiply the other side of the equation by 1/4:

$$\frac{1}{2}(mass) * (\frac{speed}{2})^2 = \frac{\frac{1}{2}(mass) * (speed)^2}{4} = \frac{F_{friction} * dist}{4} = F_{friction} * \frac{dist}{4}. \tag{5}$$

Thus, the $\boxed{\text{distance is 1/4 its original size.}}$