Hmwk # 3 Physics 107

Chapter 5: Conceptual: 22
problems: 2, 4

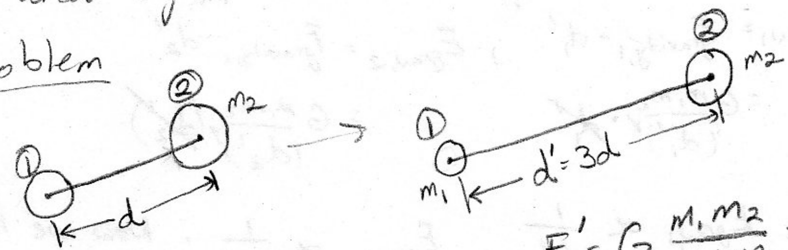
Chapter 6: Conceptual: 18
problems: 2, 6

Chapter 5: concept

22. Yes, you could make money buying at one altitude and selling at another (though you wouldn't make much) if gold were sold by weight. The force of gravity depends on the distance between the two objects. Move the two objects apart, and the force of gravity on each decreases. This would happen for the gold and the Earth. At higher altitudes the acceleration due to gravity would be less since the gold is farther from the center of the Earth. A smaller gravitational acceleration means a smaller force is exerted by the Earth on the gold, so the gold would weigh less. You would want to buy the gold at a high altitude and sell it at a low altitude. You would not make much money because the difference in the acceleration due to gravity changes very little between the lowest and highest locations on the Earth.

Ch 5: problem

2.



$$F = G\frac{m_1 m_2}{d^2}$$

$$F' = G\frac{m_1 m_2}{(d')^2} = G\frac{m_1 m_2}{(3d)^2} = G\frac{m_1 m_2}{9d^2}$$

$$= \frac{1}{9}\left(G\frac{m_1 m_2}{d^2}\right) = \underline{\frac{1}{9}F = F'}$$

The force is reduced to one ninth the original value when the distance is tripled.

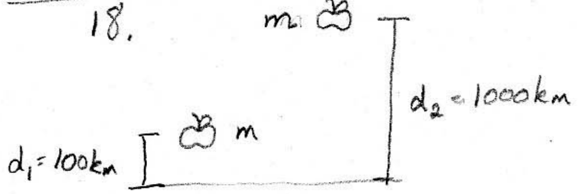
4. $m_{moon} = 7.4 \times 10^{22}\ kg$
$r_{moon} = 1.7 \times 10^6\ m$
$m_{obj} = 1\ kg$

$$F = G\frac{m_1 m_2}{d^2} = G\frac{m_{moon} m_{obj}}{r^2} = (6.7\times10^{-11}\ N\cancel{m^2}/\cancel{kg^2})\left(\frac{(7.4\times10^{22}\ \cancel{kg})(1\ \cancel{kg})}{(1.7\times10^6\ \cancel{m})^2}\right)$$

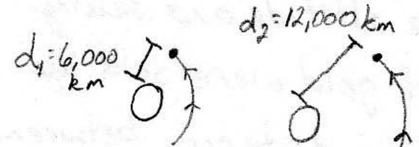
$\underline{F = 1.71 N}$

Chapter 6: concept

18.



a. Gravitational energy is related to the weight of the object and its height above a reference level. The apple weighs nearly the same at both these heights, but when it is at d_2 it is much higher. Since the the apple is much higher at d_2 with the same weight, it must have a higher gravitational energy.



Let's answer (c) before (b)

(C) From chapter 5, we know that as you move two objects apart the gravitational force between them decreases. So here, when the satellite is at 12,000 km, the gravital force acting on it is less than when it is at an altitude of 6,000 km. This means the satellite weighs less at 12,000 km.

(b) The gravitational energy of the satellite depends both on the weight and on the height. From chapter 5, we know $F_{gravity} = G\dfrac{m_1 m_2}{d^2}$. Let's redraw our picture:

$d_1' = r_{Earth} + d_1$

$d_2' = r_{Earth} + d_2$

$r_{Earth} = 6{,}000$ km (from pg 105)

$\Rightarrow d_1 = r_{Earth}\ ,\ d_2 = 2 \cdot r_{Earth}$

$\Rightarrow d_1' = 2 \cdot r_{Earth}\ ,\ d_2' = 3 r_{Earth}$

Now that we have defined all of the distances in terms of radius of the Earth, we can compare the gravitational energies.

$$E_{grav,1} = F_{grav,1} \cdot d_1 = G\frac{m_1 m_2}{d_1'} \cdot d_1 = G\frac{m_1 m_2}{2\cancel{r_{Earth}}} \cdot \cancel{r_{Earth}}$$

$$E_{grav,2} = F_{grav,2} \cdot d_2 = G\frac{m_1 m_2}{d_2'} \cdot d_2 = G\frac{m_1 m_2}{3\cancel{r_{Earth}}} \cdot 2\cancel{r_{Earth}}$$

$E_{grav,1} = G m_1 m_2 \left(\tfrac{1}{2}\right)$ $\qquad$ $E_{grav,2} = G m_1 m_2 \left(\tfrac{2}{3}\right)$ $\qquad$ $\Rightarrow E_{grav,2} > E_{grav,1}$

So the gravitational energy of the sattelite is higher at an altitude of 12,000 km.

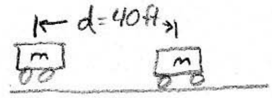
Chapter 6: problems:

2. $F_{engine} = 30,000N \Rightarrow 4 engines \Rightarrow F_{total} = 4F_{engine} = 120,000N$

$d = 1500m$

$W = F \cdot d = F_{total} \cdot d = 120,000N \cdot 1500m$

$\underline{W = 1.8 \times 10^8 \, Nm}$

6. 

$V_i \qquad V_f = 0$

$V_i' = V_i/2 \qquad V_f' = 0 \qquad d' = ?$

Kinetic energy $= KE = \frac{1}{2}mv^2$

$KE = \frac{1}{2}mv_i^2$

$KE' = \frac{1}{2}m(v_i')^2 = \frac{1}{2}m\left(\frac{v_i}{2}\right)^2 = \left(\frac{1}{2}mv_i^2\right)\left(\frac{1}{4}\right)$

$= \frac{1}{4}KE$

So, if the car were moving half as fast it would have only one fourth the kinetic energy. This means it would also only take one fourth as much work to stop the sliding car. Since work = force x distance and the force due to friction would the same in both cases, the car would only slide one fourth the distance if it had initially been travelling at half the speed.

5. 

We are applying a force to stop the car while the velocity changes from v_i to being stopped.

Initially the car has kinetic energy. We know that energy is the amount of work an object can do. After sliding, when the car is at rest, it has no kinetic energy. From conservation of energy, we know that the energy cannot dissappear. The kinetic energy goes into the work being done by the force stopping the car.

So: $KE = \frac{1}{2}mv_i^2 \qquad W = F \cdot d$

$KE = W \quad \Rightarrow \quad F \cdot d = \frac{1}{2}mv^2$

$\Rightarrow \quad d = \frac{1}{2}\frac{mv^2}{F}$

Thus: $d \propto v^2$

Now, if the car had been travelling twice as fast, it would have slid 4 times farther. $\left[d' \propto (2v)^2 = 4v^2 \Rightarrow d' = 4d\right]$