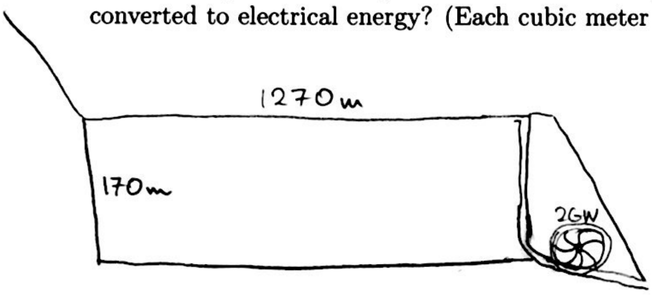
Physics 1A: Physics for Scientists and Engineers: Mechanics **Winter 2015**

Discussion 5: Week 6

Exercise 1 The Grand Coulee Dam is 1270 m long and 170 m high. The electrical power output from generators at its base is approximately 2000 MW. How many cubic meters of water must flow from the top of the dam per second to produce this amount of power if 92% of the work done on the water by gravity is converted to electrical energy? (Each cubic meter of water has a mass of 1000 kg.)



$$W_{grav} = \Delta E = mg\Delta h$$

$$\text{Power} = \frac{\Delta E}{\Delta t} = mg\frac{\Delta h}{\Delta t} = mgv = \frac{2\,GW}{92\%}$$

$$\Rightarrow \frac{m}{\Delta t} = \frac{2\,GW}{92\% \cdot g \cdot \Delta h} \Rightarrow$$

$$\Rightarrow \frac{m_{(w)}}{\Delta t} = \frac{2\,GW}{92\% \cdot g \cdot \Delta h \cdot 1000\,kg} = \frac{2 \cdot 10^6}{0.92 \cdot 9.81 \cdot 170}$$

$$= 1303\ m^3/s$$

Exercise 2 A 2.50 kg textbook is forced against a horizontal spring of negligible mass and force constant 250 N/m, compressing the spring a distance of 0.250 m. When released, the textbook slides on a horizontal tabletop with coefficient of kinetic friction $\mu_k = 0.30$. Use the work-energy theorem to find how far the textbook moves from its initial position before coming to rest.

$\mu_k = 0.3$

$$W = \Delta E = \frac{1}{2}k(\Delta x)^2 = \int F.dx = mg\mu_k \cdot x$$

$$\Rightarrow x = \frac{k(\Delta x)^2}{2mg\mu_k} = \frac{250 \cdot (0.25)^2\,m}{2 \cdot (2.5)\,9.81 \cdot 0.3} = \frac{\cancel{2.5 \times 10^2} \cdot (2.5)^2 \cdot \cancel{10^{-2}}}{2 \cdot \cancel{2.5} \cdot 9.81 \cdot 0.3}\,m$$

$$= 1.06\,m$$

Exercise 3: Classical Mechanics Laboratory. As part of your daily workout, you lie on your back and push with your feet against a platform attached to two stiff springs arranged side by side so that they are parallel to each other. When you push the platform, you compress the springs. You do 80.0 J of work when you compress the springs 0.200 m from their uncompressed length. (a) What magnitude of force must you apply to hold the platform in this position? (b) How much additional work must you do to move the platform 0.200 m farther, and what maximum force must you apply?

a) $\Delta W = \Delta E = 80J = \frac{1}{2} k_{eff} (\Delta x)^2 \Rightarrow k = \frac{160J}{(0.2)^2}$

$F = -k(\Delta x) = \frac{0.2 \cdot 160J}{(0.2)^2} = 800N \approx 80kg \cdot g$

b) $F = 1600N$, $\Delta W = 4 \cdot 80J = 320J$ from $x = 0$

$\Rightarrow$ additional $= 240J$

Challenging Problem The gravitational pull (or the gravitational force) of the earth on an object is inversely proportional to the square of the distance of the object from the center of the earth. At the earths surface this force is equal to the objects normal weight mg, and at large distances, the force is zero. If an asteroid of mass m falls to earth from a very great distance away, what will be its minimum speed as it strikes the earths surface, and how much kinetic energy will it impart to our planet? You can ignore the effects of the earths atmosphere, and the radius of the earth is R.

$F = \frac{GMm}{r^2} = mg$

$+\Delta E = \int_R^\infty F \cdot dr = \left[\frac{GMm}{R}\right] = \frac{1}{2} m v^2$

$\Rightarrow v = \sqrt{2 \cancel{M} g R_E}$