Problem Set 13: Planetary Motion and Energy Diagrams, Bohr Atom, Applications of Mechanics to Everyday Life

Design Engineering Challenge: "The Big Dig" 2.007 Contest
Pneumatic Energy Storage Concept

PROBLEM 1:

Friction will cause significant losses. Depending on the application, it can affect the performance of the machine. Ways to reduce the loss is to add a lubricant like oil or wax to the o-ring or choose one with the right surface treatment. However, 2.007 kits don't include a variety of o-rings to try or many forms of lubricant.

PROBLEM 2:

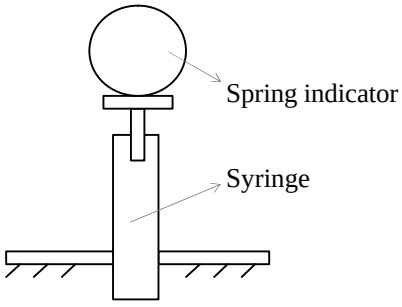
To determine how much energy you can store or use, an experiment is a fairly easy way to determine the loss. The experiment requires creating a known amount of pressure in the syringe without applying an external load. Then, add a known load such as a block and measure the motion.

Numerically, loss estimation requires that you determine or look up the coefficient of friction between the O-ring and the plastic wall and subtract the work done by the friction force from the stored energy:

$$E = W_S - W_F = W_S - m * N * x$$

Bench level experiment 1: Compress the air to a known pressure, put an object in front of it, release the syringe, and measure the distance the object moved. From the principal of work, you can determine the energy in the system. From pressure, force is found multiplying the pressure by the area of the stopper on the syringe. This force can be multiplied by the distance the object traveled to give the work done by the syringe.

Bench level experiment 2: Attach a spring indicator to the plunger. Compress the syringe then release it. Net energy output in the syringe is equal to the energy stored in the spring indicator ($.5kx^2$) where k: stiffness of the spring and x is the displaced distance.



PROBLEM 3:

How much of the steady state stored energy do you think you can actually harvest and use? Hence what is the efficiency of the air-spring energy storage system?

$$h = \frac{Measured}{Calculated} \approx 30 - 40\%$$

PROBLEM 4:

Using the constant force spring, 11.6 N of force will always be provided and no calculations are needed. For the syringe air-spring, additional losses may not be included in the calculations above. On the other hand, force from the air spring can be varied while the constant force spring can not be changed. No matter how much you extend the spring, you get the same amount of force. However, this spring stores energy much more efficiently.

PROBLEM 5:

Yes, a good reference for this technique is on the website How Stuff Works.
http://www.howstuffworks.com/