Midterm Exam

October 29, 2008, 12:00pm

You have 1 hour to complete the exam. Please answer all questions clearly and completely. Make sure that you show all of your work. Only answers written in your bluebooks will be graded.

You may use a calculator, and, of course, reference the formula sheet, attached. Beyond that, the exam is entirely closed book.

1. [25 *points*] Short Answer

   (a) [6 *points*] What are Newton's 3 laws of motion?

   (b) [8 *points*] Please name at least 2 leptons, and 2 baryons. **Note: anti-particles don't count!** For each, please tell me whether they are fundamental particles or not.

   E.C. (4 points) For any non-fundamental particles, please tell me which fundamental particles (and how many of each) comprise them.

   (c) [4 *points*] What are the mediator particles for Electromagnetism called? For the Strong nuclear force?

   (d) [7 *points*] You apply a force of $100N\hat{i} + 50N\hat{j}$ over a displacement of $\Delta\vec{r} = 2m\hat{i}$ on a 10 kg block sitting on a table. There is no friction.

      i. How much work did you do on the block?

      ii. Assuming it started from rest, how fast was it moving after you are done pushing it?

2. [10 *points*] Imagine two pieces of clay, one with mass, $m_1 = 2kg$, and with velocity, $\vec{v} = 10m/s\hat{i} - 2m/s\hat{j}$, and another with mass, $m_2 = 3kg$, and with velocity $\vec{v} = 5m/s\hat{i} + 3m/s\hat{j}$

   (a) What is the total momentum of the system?

   (b) The two pieces of clay collide and smoosh into each other. What is the velocity of the resulting blob?

3. [25 *points*] Take a rock of mass, 10kg, starting at rest, and apply a constant force of 1000N.

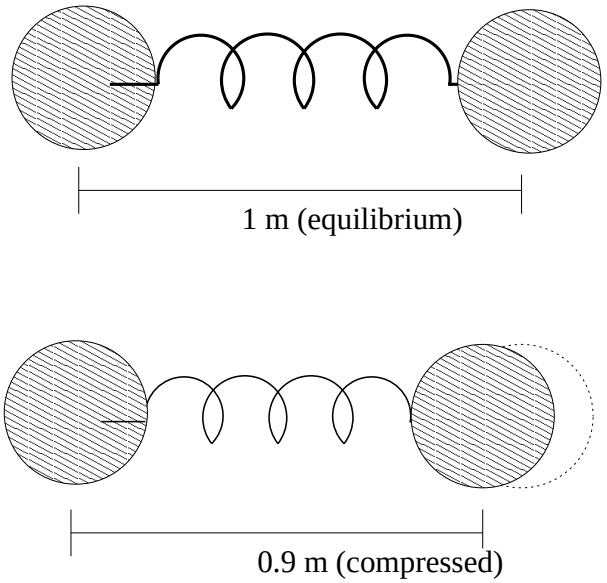
   (a) After nearly a 1 year (3×10^7 s), what is the momentum of the pebble?

   (b) What is the speed of the rock after 1 year? (Please express as a fraction of the speed of light.)

   (c) What is the *total* energy of the rock? (Note: there is no potential energy in this system)

   (d) How much work must you have put into the system?

   (e) From the work, how far must you have pushed the rock?



4. [20 *points*] You have a giant model of a diatomic molecule (i.e. two atoms connected by a spring). At rest, they are separated by 1 m, each atom has a mass of 0.2 kg, and the spring has a constant of $k_s = 200N/m$.

   You compress the molecule until the atoms are only 0.9 meters apart, and are at rest.

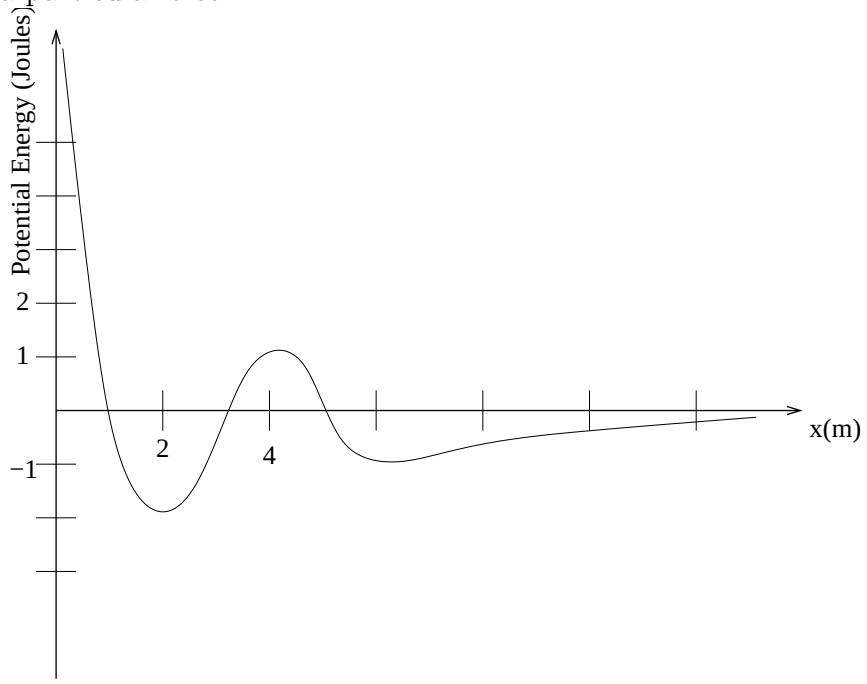
   (a) How much force do you need to apply to keep the molecule from expanding?

   (b) After compressing the atom, how much *potential* energy does the molecule have?

   (c) After compressing the molecule, you then let one end go. It begins to vibrate freely. What is the frequency of oscillation?

   (d) What is the maximum speed of oscillation?

5. [20 *points*] Consider the energy diagram in in the Figure below. It represents the amount of potential energy for a 10kg (spherical) stone to move a horizontal distance, x, from a particular tree.



(a) Starting 2 meter from the tree, what is the minimum work required to push the rock to 4m from the tree?

(b) Given that, what *average* force must you apply over that distance?

(c) Does this hillside have any equilibrium positions? If so, where are they, and are they stable or unstable.

(d) By looking at the diagram, estimate the force (including direction) on the rock when it is 3m from the tree. Which direction will it roll, if started from rest?