Midterm Exam

October 29, 2007, 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. Short Answer.

   (a) [8 *points*] Consider the neutron decay relation:

   $$n \rightarrow p + e^- + X$$

   where X is some additional particle or particles.

      i. Which of the following are conserved in this decay as written: Q, B, L (not including X)? If any of these numbers are not conserved. What are the numbers before and after the reaction?

      ii. What possible particles could be in the "X" part of the reaction in order to make all of the quantum numbers conserved?

      iii. Given your answer to the previous part, what fundamental force is at work in Neutron decay?

   (b) [7 *points*] A baseball of mass 0.1kg is travelling at 0.7c.

      i. What is the momentum of the baseball?

      ii. What is the energy of the baseball?

   (c) [4 *points*] What is the quark composition of a Neutron?

   (d) [6 *points*] You apply a force of $\vec{F} = (40\hat{i} - 10\hat{j})N$ on a block of mass 5kg. During the time you apply the force, the block $\Delta\vec{r} = 10\hat{i}\ m$.

      i. What is the work done on the block?

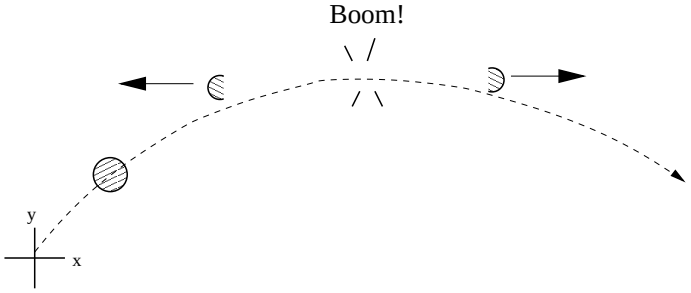
      ii. If the block had an initial speed of 4m/s, what is the speed of the block after you've pushed it?

2. [25 *points*] You throw a $0.1kg$ ball into the air from the ground with an initial velocity of

$$\vec{v} = (20\hat{i} + 15\hat{j})m/s$$

You should assume for the purpose of this problem that the potential on the ground is zero.

The path of the ball is shown (not to scale) in the figure below:



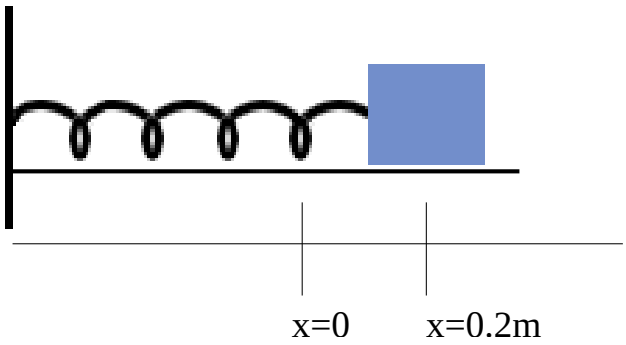
(a) If you took 0.1 seconds to throw the ball (and applied the force at a constant rate), what was the average vectoral force you gave to the ball?

(b) Please draw a free-body diagram of the forces on the ball while it's in motion (immediately after it left your hand).

(c) What is the total mechanical energy of the ball?

(d) When (after how long) does the ball reach its maximum height?

(e) At that precise instant for reasons we may never be sure of, it explodes into two equal pieces of 0.05kg. One piece travels to the horizontally to the left at 20m/s. How fast (and in what direction) does the other piece fly?



3. [25 *points*] Consider a simple harmonic oscillator with spring constant,$100N/m$ and a 4kg mass attached. It is stretched a distance of 0.2m past equilibrium and released.

   (a) For this part, consider our oscillator along with a twin, which is stretched only 0.1m (same mass, same spring constant, and released at the same time).

   Draw a sketch of the position of each mass as function of time (x(t)). Both masses should be drawn on the same plot. You do not need to put any numbers on t-axis of the plot.

   (b) What is the initial force (including direction) on the mass (the one extended 0.2m, naturally)?

   (c) How much mechanical energy is in the oscillator?

   (d) What is the maximum speed of the oscillator?

4. [25 *points*] A 10 kg mass starts off at rest. You begin by applying 1000N of force to it.

   (a) Initially, what is the acceleration?

   (b) What is the momentum of the mass after $3 \times 10^7 s$, nearly a year?

   (c) How fast is it moving at that time?

   (d) What is the γ factor of the mass at that time?

   (e) What is the total energy of the particle at that time?

   (f) **E.C.** How far did you have pushed the block during that time? (Hint: Do *not* try to invert your projectile motion equations.)