Exam 1 (October 10, 2007)

Please read the problems carefully and answer them in the space provided. Write on the back of the page, if necessary. Show your work where requested in order to be considered for partial credit. In problems where you are requested to show your work, no credit will be given unless your work is shown.

Problem 1 (4 pts, no need to show work):

A body moves with constant speed in a straight line. Which of the following statements must be true?

   a) No force acts on the body.
   b) A single constant force acts on the body in the direction of motion.
   c) A single constant force acts on the body in the direction opposite to the motion.
   d) A net force of zero acts on the body.
   e) A constant net force acts on the body in the direction of motion.

Problem 2 (4 pts, no need to show work):

An object falling near the surface of the earth has a constant acceleration of 9.8 m/s^2. This means that the

   a) object falls 9.8 m during the first second of its motion.
   b) object falls 9.8 m during each second of its motion.
   c) speed of the object increases by 9.8 m/s during each second of its motion.
   d) acceleration of the object increases by 9.8 m/s^2 during each second of its motion.
   e) force of gravity on the object is 9.8 Newtons.

Problem 3 (20 pts, no need to show work):

Put "T" next to statements you believe to be true, "F" next to statements you believe to be false, and "N" next to statements that are sometimes true and sometimes false.

____ Sir Issac Newton formulated a useful theory of gravitation.
____ Charles Coulomb discovered the fundamental nature of light in terms of electric and magnetic fields.
____ For any two people, time flows at exactly the same rate.
____ Albert Einstein invented Newton's Laws.
____ The New York Yankees baseball players are heavily overpaid.
____ An object can be moving backward while having an acceleration that is forward.
____ Objects with zero (no) net force on them do not move.
____ Light waves exhibit interference while sound waves do not exhibit interference.
____ Speed has both a direction and a magnitude (size).
____   x-rays have a longer wavelength than visible light.

Problem 4 (12 pts, no need to show work):
Briefly explain why you lurch forward in a bus that slows down suddenly?

Problem 5 (10 pts):
Sam and Fred stand on the roof of Sue B, each enjoying a twelve-ounce can of a fine beverage. When they notice someone else on the roof coming near them, Sam and Fred decide to ditch their fine beverages. Sam reaches over the edge of the roof and drops his can. Fred leans out over the edge of the roof and throws his can straight down.

If the cans leave the boys' hands simultaneously and at the same height, which can hits the ground first?

While in the air after leaving the hands, which can has the greater acceleration, or are they the same?

Problem 6 (10 pts, show work):
Earthbound doctors monitor the heartbeat of astronauts in a ship flying past earth with a speed of 0.9c. If one of the astronauts measures her heartbeat to be 70 beat/minute, what do the doctors on earth perceive her heart rate to be (in beats/minute)?

Problem 7 (12 pts):
Briefly discuss the following statement: "Scientific truths, religious truths – it's all the same. Just somebody telling somebody else how things are and what to do."

Problem 8 (18 pts):
Imagine two electrically charged particles are separated by a distance of 0.5 meters. Particle A has a mass of 2 kg and carries a positive electrical charge of +1 Coulombs. Particle B has a mass of 4 kg and carries a charge -1.5 Coulombs.

a) On the sketch below, indicate with a little arrow the direction of the electric field due to particle A at the point where particle B is located.

b) On the sketch below, indicate with a little arrow the direction of the electric field due to particle B at the point where particle A is located.

c) On the sketch below, indicate with a little arrow the direction of the electric due to both particles A and B at point C.

d) Is the electrical force between particles A and B attractive, repulsive, or is there no electrical force?

f) How does the force of particle B on particle A compare to the force of particle A on particle B?

g) How does the acceleration of particle A compare to the acceleration of particle B?

m=2kg
Q= +1C

A

m= 4 kg
Q= -1.5 C

B

C
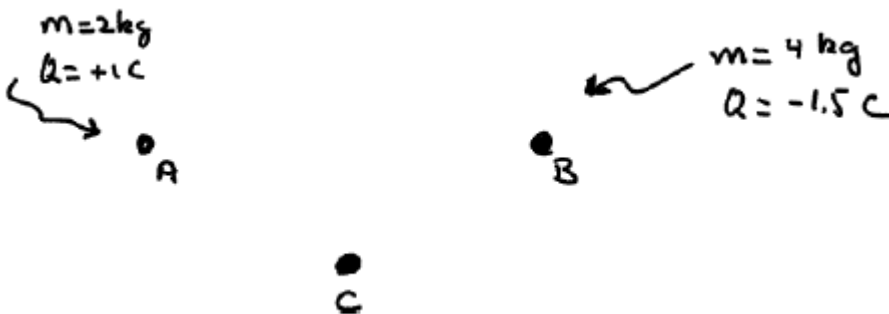
Problem 9 (10 pts, show work):

Consider a wave moving at 6 m/s on a rope. I have frozen time momentarily and sketched the wave below from a side view. What you see is the displacement of the rope from the nominal vertical position with no wave passing along the y axis versus the position along the rope along the x axis. If I unfroze time, the shape you see would move to the right at 6 m/s.

a) What is the amplitude of the wave sketched below?

b) What is the wavelength of the wave sketched below?

c) What is the frequency of the wave sketched below?

d) What is the period of the wave sketched below?
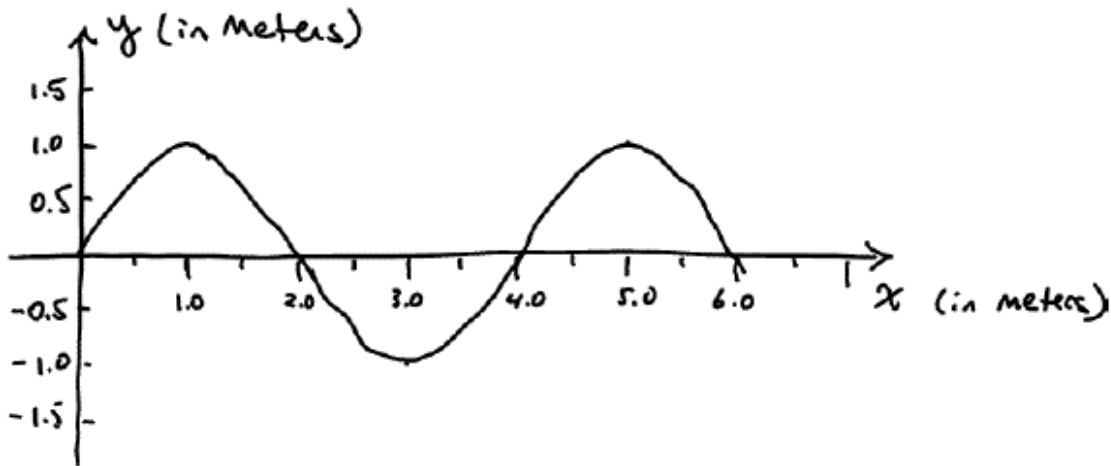
Some potentially useful formulas

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

$$c = 3 \times 10^8 \, M/s$$

$$G = 6.7 \times 10^{-11} \, \frac{N m^2}{kg^2}$$

$$F = \frac{k \, q_1 q_2}{r^2}$$

$$k = 9 \times 10^9 \, \frac{N m^2}{c^2}$$

$$F = ma$$

$$(distance) = (speed)(time)$$

$$v = \frac{\Delta x}{\Delta t}$$

$$a = \frac{\Delta v}{\Delta t}$$

Work = force × distance

Momentum = $p = mv$

$\Delta x' = \gamma \, \Delta x$, Δx longest in proper frame

$\Delta t' = \gamma \, \Delta t$, Δt shortest in proper frame

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

$$v = \lambda \nu$$

$$\nu = \frac{1}{T} \quad (T = period)$$