Exam 1 (March 2, 2009)

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):

In a vacuum, the speed of x-rays compared to the speed of visible light is

a) very much greater.
b) very much less.
c) the same
d) a little less.
e) a little greater
f) not a reasonable thing to ask for since neither x-rays or visible light can traverse a vacuum.

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

Jethro and Biff are facing each other at the exact center of a frozen circular pond. Jethro weighs twice what Biff weighs. Biff shoves Jethro toward the edge of the pond. Assume the surface of the pond is perfectly frictionless.

a) Jethro slides to the edge of the pond and Biff stays in the center.
b) Biff slides to the edge of the pond and Jethro stays in the center.
c) Neither boy moves.
d) Jethro and Biff slide to the edge of the pond and Biff reaches the edge first.
e) Jethro and Biff slide to the edge of the pond and Jeff reaches the edge first.
f) Jethro and Biff slide to the edge of the pond and reach the edge at the same time.

Problem 3 (4 pts, no need to show work):
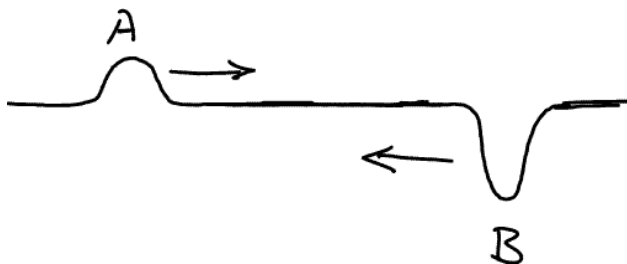
NASA's satellites stay aloft as they orbit the earth because

a) they move so fast that they are able to 'fall' around the earth.
b) they are far from the earth so that there is no gravitational force on them.
c) they have rocket engines that provide a force that holds them aloft.
d) there is no air resistance in outer space and thus no downward force on an orbiting satellite.

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

Two wave pulses are sent down a rope in opposite directions. As shown in the sketch, wave A has a height of 1 cm and wave B is 2 cm in depth. When the waves meet, they will create

a) a disturbance 3 cm high.
b) a disturbance 1 cm high.
c) a disturbance 3 cm deep.
d) a disturbance 1 cm deep.
e) no disturbance because they cancel.

Scores	
1.	___/4
2.	___/4
3.	___/4
4.	___/4
5.	___/4
6.	___/4
7.	___/7
8.	___/7
9.	___/6
10.	___/14
11.	___/12
12.	___/18
13.	___/12
Total	
___/100	

Problem 5 (4 pts, no need to show work):

If you were to travel near lightspeed and measure your own mass, pulse-rate and size, you would notice that

    a) your mass has increased.
    b) your pulse has slowed.
    c) your body has shortened along the direction of travel.
    d) all of the above.
    e) none of the above.

Problem 6 (4 pts, no need to show work):

If you were on the moon, you would find that

    a) Both your weight and mass would be increased
    b) Both your weight and mass would be reduced
    c) Your weight would be reduced, but not your mass.
    d) Your mass would be reduced, but not your weight.

Problem 7 (7 pts, no need to show work):

Calculate the photon energy for light with a wavelength in vacuum of 500 nm ($=500 \times 10^{-9}$ meters).

Problem 8 (7 pts, no need to show work):

A car moving at 48 meters per second brakes to a stop in 6 seconds. What is the average acceleration of the car?

Problem 9 (6 pts, no need to show work):

List two things that provide scientific evidence that light is a wave phenomenon.

Problem 10 (14 pts, no need to show work):

Six balls move in straight lines from left to right across the surface of a 10-meter floor. The sketches A-E below show the position of each ball (in meters) at 1-second intervals as they cross the floor (as if in a picture taken by a strobelight that flashes once every second). Take the time of the first flash to be t=0. So, the left-most image on each sketch represents the postion at t=0 seconds. For example, ball A is at postion 0 meters when the flash occurs the first time (t=0seconds) and at position 2 meters when the flash happens the second time (t=1 second) and at position 4 meters when the flash happens the third time (t=2 seconds), and so forth. Referring to the sketches below, please answer the questions that follow providing the letter(s) of the ball(s) that best answer the question. (Note that the sketches only show the ball while it is on that 10-meter section of the floor.)
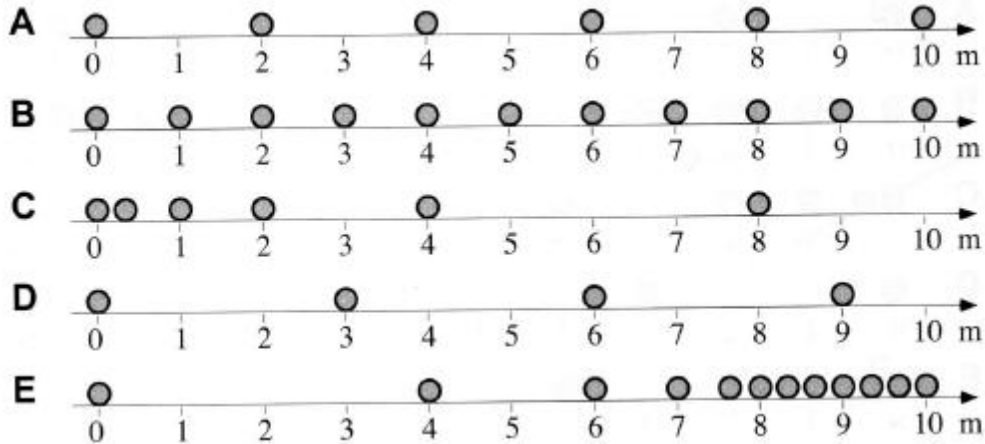
a)   Are any of the balls stationary?

b)   During the first second, which ball(s) moves the fastest?

c)   Which ball(s) move at a constant speed?

d)   Which ball(s) have positive acceleration?

e)   Which ball(s) have negative acceleration?

f)   Which ball(s) has the largest average speed as it crosses the floor?

g)   Which ball(s) has the smallest average speed as it crosses the floor?

Problem 11 (12 pts, show work):

A an electric charge Q2 = -2 coulombs and a second electric charge Q1 are situated two meters apart as shown in the sketch. If there is no electric force on a charge q = +1 coulomb that is situated 2 meters on the side of Q2 opposite of Q1, what is the electric charge of Q1?
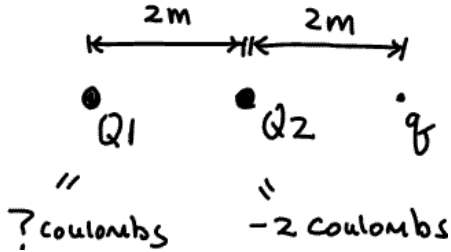
Problem 12 (18 pts, show work):

A spaceship passes football field (lengthwise) at 0.95c. You are sitting in the stands of the football field as the spaceship zips by. You know the football field is 100 yards long (which is equal to roughly 94 meters) in the direction that the spaceship travels.

How long does it take the spaceship to traverse the length of the football field from your point of view?

How long does the football field appear to the spaceship pilot?

How long does it take the spaceship to traverse the field according from the point of view of the spaceship pilot?

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Problem 13 (12 pts):

An economist was recently heard to say "A scientfic approach to solving the current economic woes in our country would be to examine the Great Depression and implement policies that either worked or, with modern hindsight, should have been implemented at the time in order to improve the situation." Briefly comment the use of the term 'scientific approach' in this statement.

Some potentially useful formulas

$$F = \frac{G m_1 m_2}{r^2} \quad \left(\begin{array}{l} m_1 \text{ and } m_2 \text{ in kg} \\ r \text{ in meters} \end{array} \right) \rightarrow G = 6.7 \times 10^{-11}$$

$$F = \frac{k q_1 q_2}{r^2} \quad \left(\begin{array}{l} q_1, q_2 \text{ in Coulombs} \\ r \text{ in meters} \end{array} \right) \rightarrow k = 9 \times 10^{9}$$

force in both cases in comes out in Newtons

$$F = ma$$

$$(\text{distance}) = (\text{speed})(\text{time})$$

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

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

Work = force × distance

Momentum = $P = mv$

$$\Delta x' = \gamma \Delta x, \quad \Delta x \text{ longest in proper frame}$$

$$\Delta t' = \gamma \Delta t, \quad \Delta t \text{ shortest in proper frame}$$

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

1 Joule = 1.6×10^{-19} eV

Speed of Sound = 330 M/s

$$C = 3 \times 10^{8} \text{ M/s}$$

$$h = 6.6 \times 10^{-34} \text{ J.s}$$
or
$$4.5 \times 10^{-15} \text{ eV.s}$$

$$\lambda = \frac{h}{P} = \frac{h}{mv}$$

$$v = \lambda \nu$$

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

$$E = h\nu$$