Exam 1 (October 14, 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 (5 pts, no need to show work):

A satellite orbits the earth at a constant speed of 18,000 miles per hour. This satellite

a) is accelerated.
b) has a changing velocity.
c) experiences both (a) and (b).
d) experiences none of the above.

Problem 2 (5 pts, no need to show work):

Jack rides a bicycle northward at 12 miles per hour. Jill rides southward on the same road at 12 miles per hour. As Jack and Jill pass each other

a) their speeds are identical and their velocities are identical.
b) their speeds are different and their velocities are different.
c) their speeds are different but their velocities are identical.
d) their speeds are identical but their velocities are different.
e) none of the above.
f) theoretical physics predicts, surprisingly enough, that they will turn into giant frogs.

Problem 3 (5 pts, no need to show work):

A scientific theory could best be described as

a) as idea that has been proven by observations of the natural world.
b) an observed fact or collection of facts about the natural world.
c) any mental picture, or idea, about the way that the natural world operates.
d) an idea that explains a large collection of observations of the natural world.
e) A tentative guess about the way the natural world operates.

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

You push your 2 kg physics book along a tabletop, pushing it with 10 newtons of force. If the book is greased so that friction is negligible, the book's acceleration is

a) 0.2 m/s^2.
b) 5 m/s^2.
c) 20 m/s^2.
d) too large to measure.
e) zero.

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

The frequency of a television signal (electromagnetic wave) is 150 x 10^6 hertz (or s^{-1}). The wavelength of this electromagnetic wave is

a) 1.0 meters.
b) 1.5 meters.
c) 2.0 meters.
d) 0.02 meters.
e) 0.5 meters.

Problem 6 (5 pts, no need to show work):

For light waves, different frequencies mean different

a) brightness.
b) colors.
c) amplitudes.
d) speeds.
e) none of the above

Problem 7 (10 pts, no need to show work):

Biff and Buffy pass each other in rocket ships at a relative velocity of half of lightspeed. Buffy has an ice cream cone that melts in five minutes if not refrigerated. She removes her cone from the refrigerator and allows it to melt. According to Biff, how long does it take for Buffy's cone to melt?

a) More than five minutes.
b) Less than five minutes.
c) Five minutes.
d) It could be more or less than five minutes depending on whether it is Buffy or Biff who is at rest.
e) It is impossible to know because insufficient information is given in the problem.

According to Buffy, how long does it take for her cone to melt?

a) More than five minutes.
b) Less than five minutes.
c) Five minutes.
d) It could be more or less than five minutes depending on whether it is Buffy or Biff who is at rest.
e) It is impossible to know because insufficient information is given in the problem.

Problem 8 (5 pts, no need to show work):

A charge of +2Q sits out in space. How does the strength of the electric field a distance D away from the charge compare to the electric field a distance 2D away from the charge (along the same radial line)?

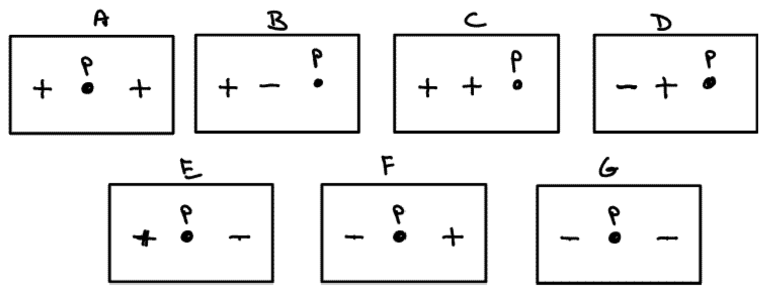
a) The field at D is the same as the field at 2D.
b) The field at D is ½ the size of the field at 2D.
c) The field at D is twice the size of the field at 2D.
d) The field at D is ¼ the size of the field at 2D.
e) The field at D is four times the field at 2D.

Problem 9 (11 pts, no need to show work):

A positive 'test' charge is placed at the point p in each of seven different situations below as shown in the seven boxes labeled A-G below. Other positive and negative charges are arranged in each box as shown.

In which situation (or situations) does the test charge at point p feel the least force due to the other charges in the box?

In which situation (or situations) does the test charge at point p feel the largest force due to the other charges in the box?



Problem 10 (11 pts, show work):

Suppose earth collapsed down to one-tenth of its present radius while retaining all of its present mass. How would your weight before the collapse compare to your weight after the collapse (assuming you survived the trauma of the geological catastrophe)?

Problem 11 (11 pts, no need to show work):

Suppose that over Thanksgiving break upon hearing that you are taking a course called Visions of the Multiverse you grandma says to you, "You know, Munchkin, I always wanted to know what people mean when they talk about the computational multiverse, which is sometimes called the simulated multiverse. Can you tell me about that?" Briefly write below what you would tell your grandma.

Problem 12 (11 pts, no need to show work):

Is the concept of an afterlife a scientific concept? Briefly defend your answer.

Problem 11 (11 pts, no need to show work):

Powerful rockets that send payloads into orbit are typically designed in multiple "stages". That is to say the rocket is generally two or three distinct rockets in a stack. When the rocket is launched initially, the lowest stage – or rocket – is ignited. When the lowest stage runs out of fuel, it is disconnected from the rising rocket and falls to earth while the second stage – second to lowest in the stack of rockets – ignites and pushes the rocket. If there is a third stage to the rocket, the process continues. Briefly explain the advantage this multiple stage rocket design has over the design of a single large rocket (single stage design).

Some potentially useful formulas

$F = \frac{G m_1 m_2}{r^2}$ (m_1 and m_2 in kg, r in meters) $\rightarrow G = 6.7 \times 10^{-11}$

$F = \frac{k q_1 q_2}{r^2}$ (q_1, q_2 in Coulombs, r in meters) $\rightarrow k = 9 \times 10^{9}$

in both cases force comes out in Newtons

$F = ma$

(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

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

1 Joule = 1.6×10^{-19} eV

speed of sound = 330 m/s

$c = 3 \times 10^{8}$ m/s

$v = \lambda \nu$

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

gravitational force at earth's surface

$F = mg$ where

$$g = \frac{G M_E}{R_E^2} = 9.8 \text{ m/s}^2$$