P100 University of Rochester NAME Soln key - SM
S. Manly Spring 2009

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.

x-rays and visible light are forms of electromagnetic radiation and travel at $c = 3\times10^8$ m/s in 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.
4 - [✓ 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.
2 - f) Jethro and Biff slide to the edge of the pond and reach the edge at the same time.

During push Force is the same on each boy. Biff accelerates more because his mass is less. So Biff moves faster toward edge of pond.

Problem 3 (4 pts, no need to show work):

NASA's satellites stay aloft because

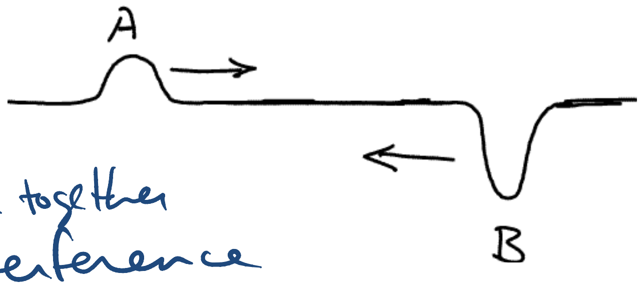
← gravity Always pulls them toward Earth

4 - [✓ a)] they move so fast that they are able to 'fall' around the earth.
b) they are far from Earth so that there is no gravitational force on them.
1 - c) they have rocket engines that provide a force that holds them aloft. — only during launch
1 - 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.
4 - [✓ d)] a disturbance 1 cm deep.
2 - e) no disturbance because they cancel.



Waves add together via interference

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

Wow! ☺

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.
2 - d) all of the above.
4 - [✓ e)] none of the above.

No change since you are measuring things in your own reference frame

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
1 - 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 ($=500\text{x}10^{-9}$ meters).

Need ν from $c = \lambda\nu$, Then get E from $E = h\nu$

$3\times10^{8}\,m/s = 500\times10^{-9}\,\nu$

$\nu = 6\times10^{14}\,s^{-1}$

$E = h\nu$

$E = (4.1\times10^{-15}\,eV\,s)(6\times10^{14}\,\frac{1}{s})$

$E = 2.5\,eV$

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?

Average Acceleration $= \frac{\Delta V}{\Delta t} = \frac{0-48}{6-0} = -8\ m/s^2$

(give 5 pts if answer is $+8\ m/s$)

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

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

2 of

Refraction

Diffraction

Interference

Dispersion

This is what I'm looking for but other answers might be okay too.

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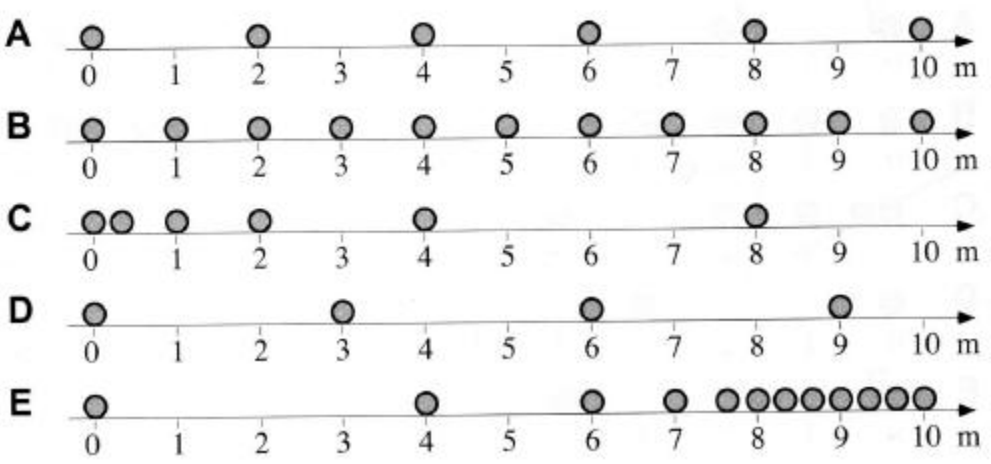
Problem 10 (14 pts, no need to show work):

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.



(2 points per part, 1 point/part Awarded if Some of Answer correct while some is incorrect)

a) Are any of the balls stationary? No

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

c) Which ball(s) move at a constant speed? A, B, D

d) Which ball(s) have positive acceleration? C

e) Which ball(s) have negative acceleration? E

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

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

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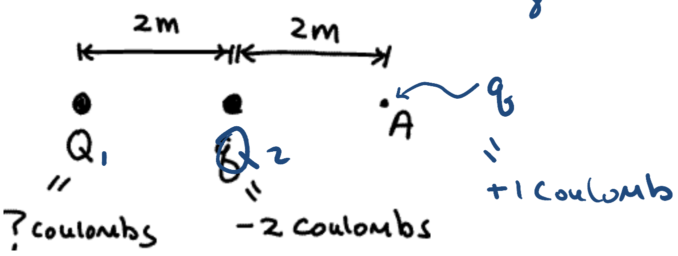
Problem 11 (12 pts, show work):

A an electric charge q = -2 coulombs and a second electric charge Q are situated two meters apart as shown in the sketch. If the ~~electric field is~~ zero at a point A 2 meters on the side of q opposite of Q, what is the electric charge of Q? Force on Q' is zero



Force of Q_2 on q must cancel with force of Q_1 on q

$$F = 0 = \frac{kQ_1 q}{(4)^2} + \frac{kQ_2 q}{2^2}$$

$$0 = \frac{kQ_1(+1)}{4^2} + \frac{k(-2)(+1)}{2^2}$$

$$\leftarrow \frac{k2}{4} = \frac{kQ_1}{16}$$

$$\boxed{Q_1 = +8 \text{ coulombs}}$$

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?

$\underbrace{\text{distance} = (\text{velocity})(\text{time})}_{\text{All from your point of view}}$

$94 \text{ meters} = (0.95)(3\times10^8 \text{ m/s})\, t$

$t = 3.3\times10^{-7}$ s

or

0.00000033 s

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

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{.95c}{c}\right)^2}} = 3.2$$

Proper frame of football field is your frame not pilots

length contraction → length longest in proper frame

$$L_{pilot} = \frac{L_{you}}{\gamma}$$

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

$$L_{pilot} = \frac{94 \text{ meters}}{3.2}$$

$$\boxed{\sim 29 \text{ meters}}$$

Field seems to go by at 0.95c and looks 29 meters long to pilot

so $29 \text{ meters} = 0.95(3\times10^8)\, t$

$t = 1\times10^{-7}$ s $= 0.0000001$ s

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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.

Using the past experience from the Great Depression to aid in making policy is a "scientific approach" because you are using information from a previous observation of a similar event to construct models and generate ideas to alleviate the economic downturn.

Calling this a "scientific approach" is being very generous however. Times change and many variables are involved. We are not in a time that is "repeating the experiment" of the Great Depression. The economy is significantly more globalized and information flow is instantaneous now relative to then, for example. In science, conclusions are drawn from repeated, controlled experiments insofar as possible. That is very much not the case here.

Answers can vary...
Really looking for student
to show some awareness of
how science works as
they support or criticize
(or both) the statement