P100 University of Rochester NAME Soln key - SLM
S. Manly Fall 2007

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 (~~8~~ 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?

2 – 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.
4 – 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 (~~8~~ 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

2 – 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.
4 – c) speed of the object increases by 9.8 m/s during each secod 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.

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

Will also accept N, F

T is 1 pt ans.

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Scores
1. ___/8
2. ___/8
3. ___/20
4. ___/12
5. ___/10
6. ___/10
7. ___/12
8. ___/10
9. ___/10

Total ___/100

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

By Newton's 1st law a body in motion persists in that motion unless acted on by a net force. When the bus slows down your body continues to move at the same speed until slowed down by the force of friction of the seat on your bottom or the force of your hand on the hand bars or seat in front of you. It feels as if you lurch forward when what is really happening is that you aren't stopping as fast.

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?

The can that is thrown (Fred's) hits the ground 1st.

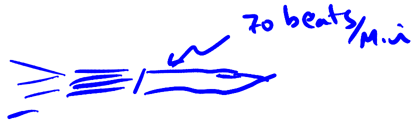
While in the air after leaving the hands, which can has the greater acceleration, or are they the same?

Both cans experience the same force after leaving the hands. Just the force due to gravity ... same for both. $F=ma$ means accelerations are 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)?

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{.9c}{c}\right)^2}} = 2.3$$

Time for 1 heartbeat in "proper" frame on spaceship
$= \frac{1}{70}$ min $= 0.014$ min



Time meas on earth longer ... time dilation

$\Delta t' = \gamma \, \Delta t$ $= (2.3)\frac{1}{70}$ min $= 0.03$ min per beat
↑ Proper time

$\frac{1}{.03 \text{ min/beat}} = 33$ beats/min

Meas. to be 33 beats/min on earth

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."

Religious truth is a matter of opinion/faith. It is NOT necessary for religious truth to be consistent with experimental observations. Science really has NO truths, so to speak. Science bows to experiment. One experimental observation that contradicts a dearly held belief is sufficient to overthrow (or necessitate modification in) that belief/idea.
Science does not urge anyone to do anything. There is NO moral system tied up in science. However scientific facts can be used to help motivate people to take one course of action over another.

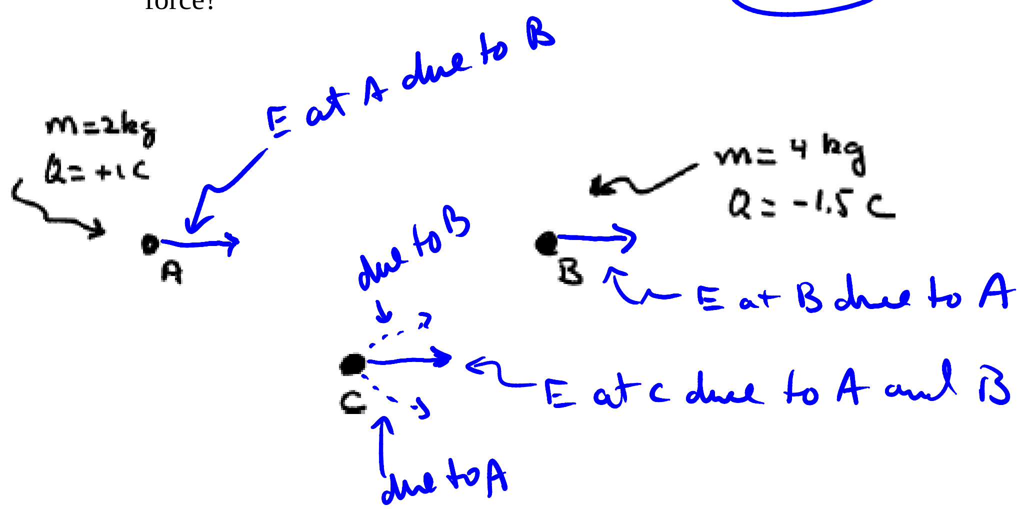
Problem 8 (~~10~~ pts): 18 pts
Imagine two electrically charged particles are separated by a distance of 0.5 meters. Particle A has a mass of 2 kg and carries a positive electrical charge of +1 Coulombs. Particle B has a mass of 4 kg and carries a charge -1.5 Coulombs.

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?



$F_A = F_B$

$M_A a_A = M_B a_B$

$\frac{a_A}{a_B} = \frac{M_B}{M_A} = \frac{4}{2} = 2$

Accel A = 2 Accel B
opposite directions

e) How does the force of A on B compare to that of B on A?
→ The same in magnitude, opposite in direction

f) How does the Accel of A compare to that of B?

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? 1 m

b) What is the wavelength of the wave sketched below? 4 m

c) What is the frequency of the wave sketched below? 1.5 Hz or 1.5 $\frac{1}{s}$

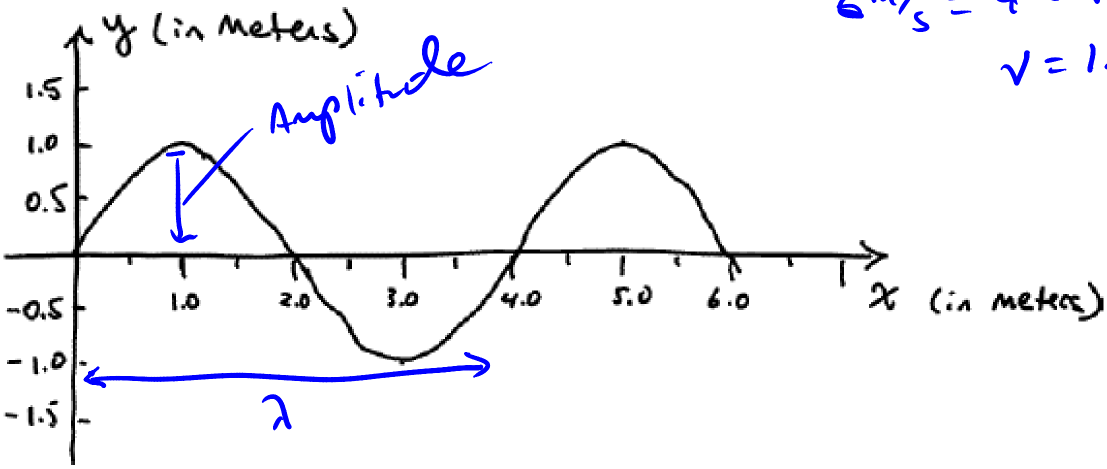
d) What is the period of the wave sketched below?

$$T = \frac{1}{\nu} = .66\ s$$

$$v = \lambda \nu$$

$$6\,\text{m/s} = 4\,\text{m}\,\nu$$

$$\nu = 1.5\ \frac{1}{s}$$



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

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

$v = \lambda \nu$

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