MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

Physics 8.01 Spring 2005

WEEKLY QUIZ 1 SOLUTIONS

Friday, February 4, 2005

FAMILY (LAST) NAME

GIVEN (FIRST) NAME

STUDENT ID NUMBER

Please check (✔) your class ☞

	L01	MTW 11:00	Walter Lewin
	L02	MTW 11:00	Walter Lewin
	L03	MTW 2:00	Min Chen
	L04	MTW 3:00	Min Chen

INSTRUCTIONS:

1. FORMULA SHEET is in the back of this exam. You may tear it off. There is also a BLANK PAGE in case you need it.
2. This is a closed book exam. CALCULATORS, BOOKS, and NOTES are NOT ALLOWED.
3. Unless otherwise stated, to earn full credit you must show a valid DERIVATION and/or EXPLANATION of your answer, and you must express it in terms of the GIVEN VARIABLES.

Problem	**Maximum**	**Score**	**Grader**
1	20		
2	30		
3	30		
4	20		
TOTAL	100		

Name

Problem 1: Unit conversions (*20 points*)

(a) (*10 points*) Suppose the speed of bullet is 1000 feet per second. Using 1 mile ≈ 5000 feet, what is the speed in miles per hour?

$$1000\ \frac{\text{ft}}{\text{s}} = \cancel{1000}\ \frac{\cancel{\text{ft}}}{\cancel{\text{s}}} \times \left(\frac{1\ \text{mi}}{\underset{\cancel{5}}{\cancel{5000}}\ \cancel{\text{ft}}}\right) \times \left(\frac{\overset{12}{\cancel{60}}\ \cancel{\text{s}}}{\cancel{\text{min}}}\right) \times \left(\frac{60\ \cancel{\text{min}}}{\text{hr}}\right) = \boxed{720\ \frac{\text{mi}}{\text{hr}}}\ .$$

(b) (*10 points*) A piece of aluminum foil has a mass per area equal to 0.01 g/cm^2. What is its mass per area in kg/m^2.

$$0.01\ \frac{\text{g}}{\text{cm}^2} = 0.01\ \frac{\cancel{\text{g}}}{\cancel{\text{cm}}^2} \times \left(\frac{\text{kg}}{1000\ \cancel{\text{g}}}\right) \times \left(\frac{100\ \cancel{\text{cm}}}{\text{m}}\right)^2 = \boxed{0.1\ \frac{\text{kg}}{\text{m}^2}}\ .$$

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Problem 2: Two runners on a circular track (*30 points*)

Two runners start simultaneously from the same point on a circular track of circumference ℓ, and run in the same direction. The first runs at a constant speed v_1, and the second runs at a constant speed v_2, which is faster.

(a) (*5 points*) After a time t, how much distance has the first runner traveled?

$$\boxed{s_1 = v_1 t \ .}$$

(b) (*15 points*) When will the faster runner overtake ("lap") the slower one?

One runner will lap the other when she has run a distance ℓ further:

$$v_2 t = v_1 t + \ell \quad \Longrightarrow \quad \boxed{t = \frac{\ell}{v_2 - v_1} \ .}$$

(c) (*5 points*) When the faster runner overtakes the slower one, how much distance has the faster runner traveled?

$$s_2 = v_2 t = \boxed{\frac{v_2 \ell}{v_2 - v_1} \ .}$$

Problem 3: Average velocity, instantaneous velocity, and distance (*30 points*)

A toy train is moving along a linear track. Its distance from the start of the track at time t is given by

$$x(t) = At + Bt^2 + Ct^5 ,$$

where A, B, and C are constants.

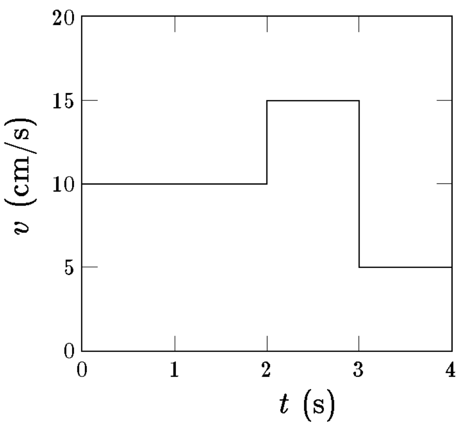
(a) (*10 points*) At time t_1, what is the instantaneous velocity of the train?

$$v = \frac{\mathrm{d}x}{\mathrm{d}t} = \boxed{A + 2Bt + 5Ct^4 .}$$

(b) (*10 points*) Between time $t = 0$ and $t = t_1$, what is the average velocity of the train?

$$v_{\mathrm{av}} = \frac{\Delta x}{\Delta t} = \frac{x(t_1) - x(0)}{t_1} = \boxed{\frac{At_1 + Bt_1^2 + Ct_1^5}{t_1} .}$$

(c) (*10 points*) Now suppose instead that the train has a velocity $v(t)$ given by the following graph:



How far has the train traveled between $t = 0$ and $t = 4$ s?

From $t = 0$ to $t = 2$ s, $\Delta x = 10$ cm/s $\times$ 2 s = 20 cm
From $t = 2$ s to $t = 3$ s, $\Delta x = 15$ cm/s $\times$ 1 s = 15 cm
From $t = 3$ s to $t = 4$ s, $\Delta x = 5$ cm/s $\times$ 1 s = 5 cm
So, from $t = 0$ s to $t = 4$ s, $\Delta x = (20 + 15 + 5)$ cm = $\boxed{40 \text{ cm} .}$

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Problem 4: Seconds of Life (*20 points*)

A typical human lifespan is 70 years. To one significant figure, how many seconds does a typical person live?

One might know that one year is about $\pi \times 10^7$ *seconds, but if one doesn't one can work it out:*

$$1 \text{ yr} = 1 \text{ yr} \times \left(\frac{365 \text{ day}}{\text{yr}}\right) \times \left(\frac{24 \text{ hr}}{\text{day}}\right) \times \left(\frac{60 \text{ min}}{\text{hr}}\right) \times \left(\frac{60 \text{ s}}{\text{min}}\right) \approx 3 \times 10^7 \text{ s} .$$

Then,

$$70 \text{ yr} \approx 70 \times 3 \times 10^7 \text{ s} \approx \boxed{2 \times 10^9 \text{ s} .}$$

10^9 *is called a billion, so a typical person lives 2 billion seconds.*