

**UNIVERSITY OF TORONTO**  
**Faculty of Arts and Science**

**DECEMBER 2009 EXAMINATIONS**

**PHY 100H1F**  
**The Magic of Physics**

**Duration = 3 hours**  
**No Aids Allowed**

**Instructions:**

Answer **ALL** twelve of the following questions. You may use pen or pencil. Please write legibly.

Write all of your responses in the examination booklets provided. Before starting, please **PRINT** your name, student number, and tutorial group code (or tutor's name) on the front page of your booklet. If you use more than one booklet, make sure that you put this information on every booklet, numbering each one.

Marks will be given for your explanations as well as for final answers. Total marks = 100.

Standard gravitational acceleration	g	10 m/s <sup>2</sup>
Speed of light in a vacuum	c	3.0 × 10 <sup>8</sup> m/s
Planck's constant	h	6.6 × 10 <sup>-34</sup> J s

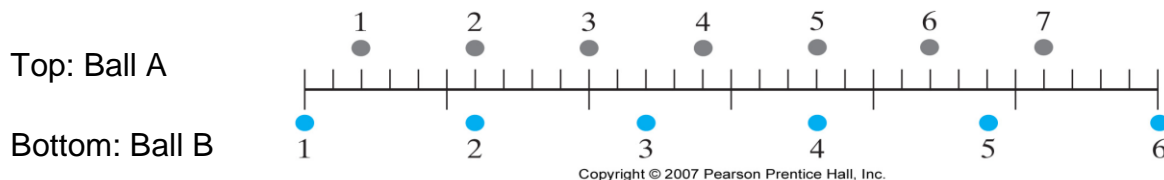
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**SHORT ANSWER QUESTIONS**

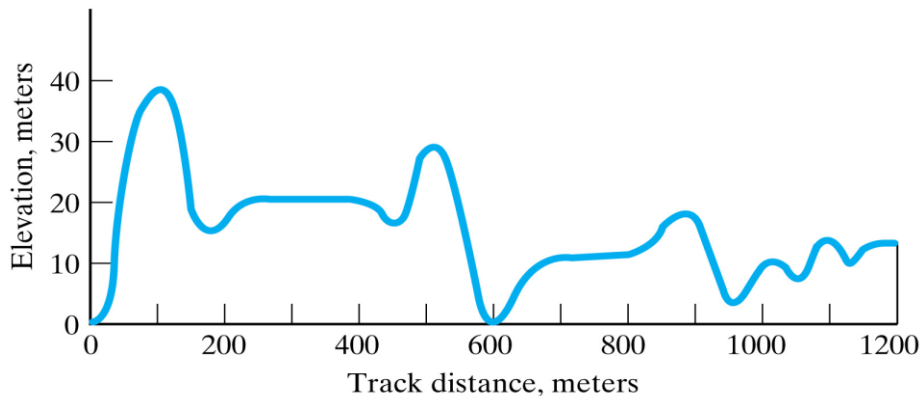
**[8 marks each – 4 marks for part (a) and 4 marks for part (b) – for 80 marks total]**

For each of the following ten questions, provide a short answer. It need not be more than a few words and numbers, or a single sentence, but should briefly explain your reasoning.

1. (a) What does the Law of Inertia say about the velocity of an object that is subject to no external influences? What does this law say about the acceleration of such an object?
- (b) The figure below represents a multiple-flash photo of two balls moving from left to right. The figure shows both balls at several numbered times. The flash times are equally spaced. Which ball has the greater acceleration? Which ball has the greater speed? Which ball has the greater velocity? Which ball passes the other, and when?



2. (a) Briefly describe two experiments demonstrating that forces come in pairs.
- (b) A 2 N apple hangs by a string from the ceiling. Describe the two forces on the apple, including their direction and their magnitude relative to each other. Do these forces form a single force pair? If not, then for each force, describe the other member of that force's force pair.
3. (a) If you were orbiting Earth in a satellite 200 km above the ground, would you be weightless? Would your weight be as large as it is when you are on the ground? Would you feel weightless? Explain.
- (b) If gravity suddenly shut off right now, what would be the shape of Earth's orbit? What would be the shape of the moon's orbit?
4. (a) An apple in a tree has 90 J of gravitational energy relative to the ground. It falls. If you neglect air resistance, what can you say about the amount of kinetic energy the apple has just before it hits the ground? What can you say if you do not neglect air resistance?
- (b) The figure below is a graph of a roller coaster's height above the ground versus the length of track it covers. The roller coaster is powered up to its high point at 100 m along the track from the starting point. From this high point, the roller coaster coasts freely all the way to the end. Assume that the roller coaster starts from rest at the high point and encounters no friction or air resistance. Is the roller coaster moving faster at 1000 m or at 1100 m? Describe how the roller coaster's speed changes during the last 300 m, from 900 m to the end of the track at 1200 m.



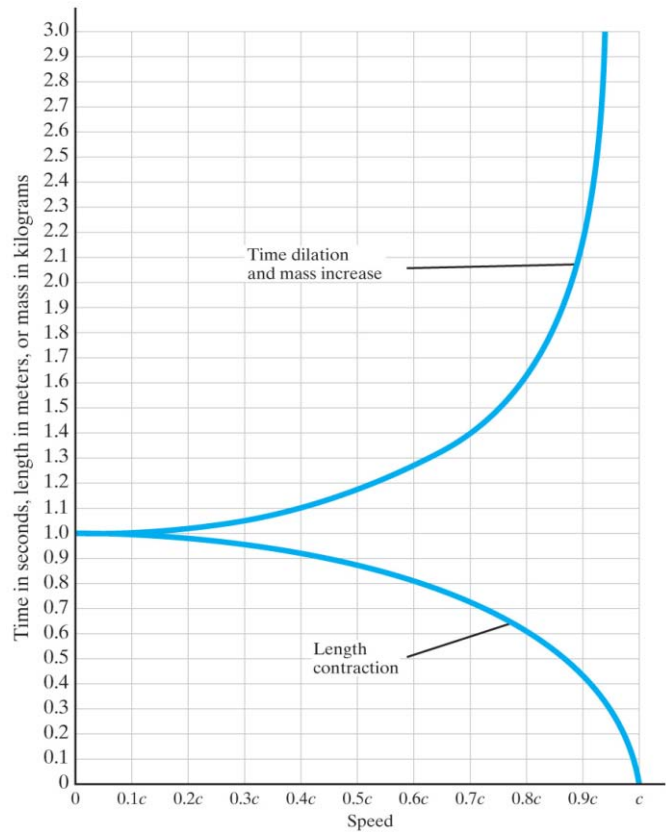
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5. (a) Two continuous water waves each have an amplitude of 2 cm. What is the displacement of the water's surface: (i) when a crest of one wave meets a trough of the other? (ii) when a crest of one wave meets a crest of the other? (iii) when a trough of one wave meets a trough of the other? Explain your answers very briefly.
- (b) A proton is placed at rest at some point A within a room that is otherwise empty of all matter. At some other point B within the room, is there: (i) an electric field? (ii) an electric force? (iii) a magnetic force? (iv) energy? Explain your answers very briefly.

6. (a) Outline the process by which chlorofluorocarbons (CFCs) destroy ozone in the stratosphere.
- (b) What is a feedback effect? Explain the difference between positive and negative feedback effects. Describe one feedback effect related to global warming.

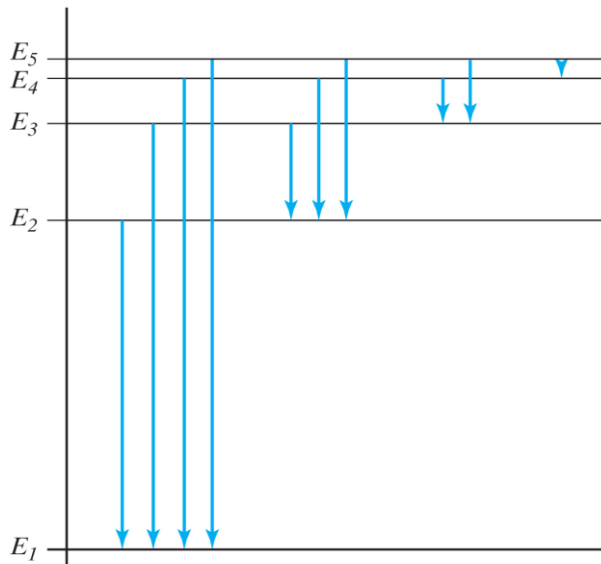
7. (a) Velma passes Earth moving at 50% of lightspeed. On her video player, she watches a taped video program that runs for 1 hour. How long does the program run as measured by an Earth-based observer? Draw the worldline for Velma.
- (b) How fast must Velma move past Mort if Mort is to measure her spaceship's length to be reduced by 50%? If Velma is flying over Canada (about 5000 km wide) at this speed, how wide will she measure Canada to be?

You may find the figure to the right useful. It shows the relativistic time dilation, length contraction, and mass increase.



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8. (a) An electron and an antielectron annihilate each other. In this process, is energy conserved? Is mass conserved? Is rest mass conserved?
- (b) According to current theories, is there dark matter in your room? Why can't you see dark matter? Since dark matter is invisible, why do scientists think that it exists? Why do scientists think that dark energy exists?
9. (a) A light beam that is initially red has a variable frequency. As you increase the frequency, does the colour change? Do the energies of the individual photons increase, decrease, or remain the same? Which has a shorter wavelength, a slow electron or a fast electron?
- (b) The figure below shows the possible downward quantum jumps between the five lowest energy levels of the hydrogen atom. Which quantum jump creates the photon with the highest frequency? Which quantum jump creates the photon with the longest wavelength? Explain your answers.



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10. (a) Radon ( $^{222}_{86}\text{Rn}$ ) has a half-life of 4 days. Starting with 100 atoms of radon, how many will remain after 12 days? Is this a precise prediction?
- (b) (i) An alpha particle is removed from  $^{16}_8\text{O}$ . Is this an example of fusion or fission? Write down the nuclear reaction formula for this reaction. Which side of this reaction formula, the left or the right, represents more nuclear energy? (ii) Before it exploded, the 1987 supernova fused many elements. In one reaction,  $^{12}_6\text{C}$  fused with  $^4_2\text{He}$ . What nucleus did this create? Did this reaction release nuclear energy?

### ESSAY QUESTIONS [10 marks each, for 20 marks total]

For each of the following two questions, write a 2 or 3 paragraph (one-page maximum for each) essay. Explain your thoughts clearly, as though writing for a member of your class who may not already know about this topic. If you wish, you may include sketches to illustrate concepts.

11. What is chaos? What are some of the characteristics of chaotic systems? Define an attractor, a strange attractor, and the Lorenz attractor. Discuss how Lorenz devised the equations for the Lorenz attractor and what physical system he was studying. Give one other example of a chaotic system.
12. The double slit experiment has provided fundamental insights into the nature of both light and matter. Describe both versions of the experiment, the results, and their significance.

**END**

**Total marks = 100**

**Total Pages = 4**