

UNIVERSITY OF TORONTO
Faculty of Arts and Science

APRIL 2012 EXAMINATIONS

PHY 100H1S
The Magic of Physics

Duration – 3 hours

No Examination 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, tutorial group code, and 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 ²
Speed of light in a vacuum	c	3.0 × 10 ⁸ m/s
Planck's constant	h	6.6 × 10 ⁻³⁴ J s

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 few sentences, but you should explain your reasoning in all cases.

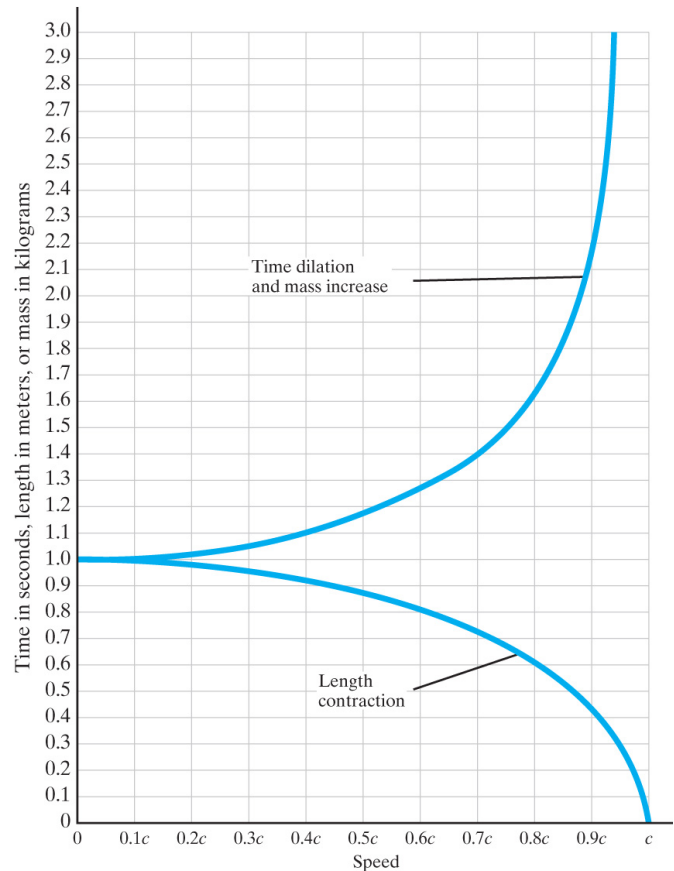
- (a) If you ride on a smooth, fast train at an unchanging speed and throw a baseball upward inside the train, will the baseball then get left behind and come down toward the rear of the train? Explain your answer.

(b) An automobile moves along a straight highway at an unchanging 80 km/hr. During the motion, which of the following quantities change, and how do they change: (i) distance from the starting point, (ii) speed, (iii) velocity, and (iv) acceleration. Explain your answers.

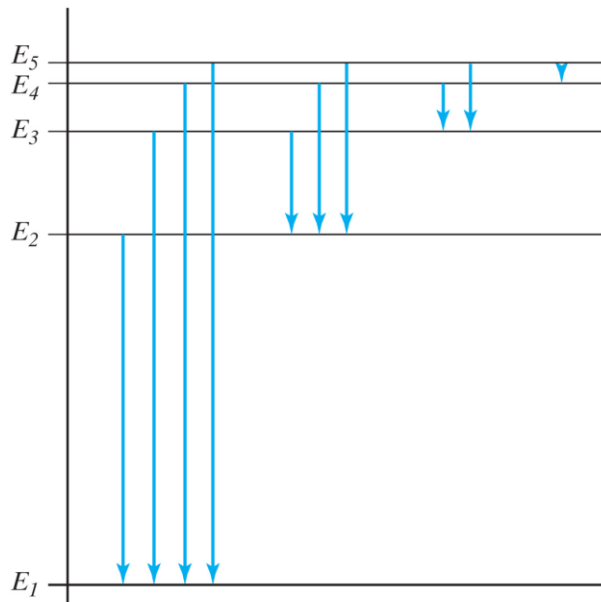
2. (a) A 2 N apple hangs by a string from the ceiling. Describe the two forces on the apple. How strong is each of these forces? Do these forces form a single force pair? If not, then for each force, describe the other member of that force's force pair.
- (b) You are holding an apple in your hand. In the following, compare the apple's weight and the force exerted on the apple by your hand. (i) Which is larger, the apple's weight or the upward force by your hand, if you accelerate the apple upward while it is in the palm of your hand? (ii) Which is larger if you accelerate the apple downward while it is in the palm of your hand? (iii) Which is larger if you lift the apple at an unchanging velocity? (iv) Which is larger if you lower the apple at an unchanging velocity?
3. (a) What would happen to the weight of a book if you managed to double Earth's mass? What would happen to the weight of the book if you doubled the book's mass? What would happen to the weight of the book if you managed to double both the mass of Earth and the mass of the book? Explain your answers.
- (b) If gold were always sold by weight, could you make money buying gold at one altitude above the ground and selling it at a different altitude? Where would you want to buy, at a high altitude or a low altitude? Explain your answers.
4. (a) You throw a baseball. Describe two ways that you could determine how much work you did during the throw. For each method, state which quantities you would need to measure and how you would use them to calculate the work done.
- (b) You throw the same baseball upwards and then catch it at the same height from which it was thrown. How does the ball's final speed compare with its initial speed: (i) neglecting air resistance, and (ii) including air resistance. Explain your answers.
5. (a) While brushing your hair, you find that the hairs tend to stand apart from one another and that they are attracted toward the brush. Explain this in microscopic terms.
- (b) If you place a proton at some point in an electric field and then release it, what will happen? How would the proton's motion differ from the motion of an electron placed at the same point in the same electric field? What would happen to the proton and the electron if the field were gravitational instead of electric? Explain your answers.
6. (a) The total quantity of energy that reaches Earth in the infrared region of the electromagnetic spectrum is greater than that in the ultraviolet region. Why then are we more concerned about the direct health effects of UV than of IR? Why can you get sunburn even on a cloudy day? Why do you not get sunburn, even on a sunny day, if you are behind glass?
- (b) Describe a space-time diagram for motion in one dimension, and define the term "worldline". On a single space-time diagram, draw the worldlines for three objects, one at rest, one moving in the $+x$ direction at constant speed v , and one moving in the $-x$ direction at constant speed v . Use another space-time diagram to show how the Theory of Special Relativity forbids time travel to the past.

7. (a) Does the Special Theory of Relativity allow you to go on a trip and return older than your father? Does the Special Theory of Relativity allow your father to go on a trip and return younger than you?
- (b) A meter stick with a rest mass of 1 kg moves past you. Your measurements show it to have a mass of 2 kg and a length of 1 m. What is the orientation of the stick, and how fast is it moving?

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



8. (a) In the Equivalence Principle, what is equivalent to what? Why don't we notice the gravitational bending of light on Earth? Does the path of a high-speed bullet bend more or less than the path of a light beam? Explain your answers.
- (b) What is the universe mostly made of? Cosmologists did not expect to find that the universe is accelerating - what did they expect? Since the universe is accelerating as it expands, is there any doubt among cosmologists that the fate of the universe is to expand forever? Explain your answers.
9. (a) Which has a shorter wavelength, an electron or a proton moving at the same speed? List some similarities between an electron beam and a light beam.
- (b) The figure on the next page shows the ten possible downward quantum jumps between the five lowest energy levels of the hydrogen atom. Which quantum jump creates the photon with the lowest frequency? Which quantum jump creates a higher-frequency photon: E_4 to E_3 or E_4 to E_2 ? Which of these two photons has the longer wavelength? Explain your answers.



10. (a) Earth is about 4.5 billion years old. Roughly how much more $^{235}_{92}\text{U}$ was there on the newly formed Earth than there is today? Note: Uranium ($^{235}_{92}\text{U}$) has a half-life of 0.7 billion years.
- (b) (i) Which of the four fundamental forces holds the nucleus together? Which one of the four forces tends to push the nucleus apart, that is, to separate into pieces?
(ii) When a $^{235}_{92}\text{U}$ nucleus is struck by a neutron, it splits into a pair of large fragments and emits two to four neutrons. A typical pair of fragments is $^{142}_{56}\text{Ba}$ and $^{91}_{36}\text{Kr}$. Write a reaction equation showing the isotopes and other particles that go into and come out of this reaction.

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, single-spaced, 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. Write an essay on global warming, including some discussion of the greenhouse effect, emissions of greenhouse gases, evidence for the impact of human activity, and the predictions of climate models.
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