PHY 2060 Spring 2007 — Exam 1

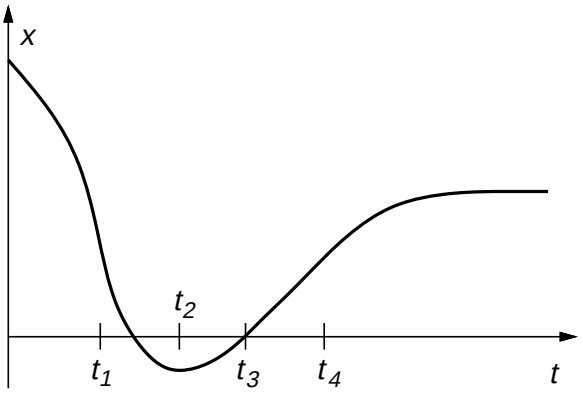
DO NOT TURN THE PAGE UNTIL INSTRUCTED TO DO SO

Instructions: Attempt all ten questions, each of which carries a maximum of 10 points. Write your solution below each question, continuing on on additional paper if necessary. Please try to write neatly!

You will receive credit only for knowledge and understanding that you demonstrate in your written solutions. It is in your best interest to write down something relevant for every question, even if you can't provide a complete answer. To maximize your score, you should briefly explain your reasoning and show all working. (This may benefit you even in the case of the multiple-choice Question 1.) Give all final algebraic answers in terms of variables defined in the problem, g (the acceleration due to gravity near the Earth's surface), and/or c (the speed of light). For numerical problems, take $g = 10\,\mathrm{m/s^2}$ and $c = 3.0 \times 10^8\,\mathrm{m/s}$.

During this exam, you may use one formula sheet and an electronic calculator. You are not permitted (a) to consult any other books, notes, or papers, (b) to use any other electronic device, or (c) to communicate with anyone other than the proctor. In accordance with the UF Honor Code, by turning in this exam to be graded, you affirm the following pledge: *On my honor, I have neither given nor received unauthorized aid in doing this assignment.*

1. (a) The graph below shows the position x versus time t for an object moving in one dimension.



Place a check to the left of any/all of the following statements that is/are true:

i. The object has its maximum speed between times t_3 and t_4.

ii. The object's acceleration is greatest in magnitude near time t_1.

iii. The object's acceleration is approximately constant between times t_3 and t_4.

iv. The object is stationary at time t_3.

(b) A projectile is launched at an angle of 45° above horizontal ground. During its flight, the projectile experiences drag due to air resistance. Place a check to the left of any/all of the following statements that is/are true:

i. The object instantaneously experiences zero acceleration at the highest point of its trajectory.

ii. The horizontal component of the object's velocity is decreasing in magnitude at every moment of the flight.

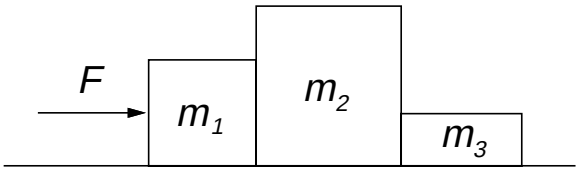
iii. The object travels a greater horizontal distance during the first half of its flight time than it does during the second half.

iv. The vertical component of the object's velocity is decreasing in magnitude at every moment of the flight.

v. The vertical component of the object's acceleration is constant.

vi. The object instantaneously experiences zero drag at the highest point of its trajectory.

2. Three blocks are in contact on a horizontal, frictionless table. A force of magnitude F is applied to the left-most block, as shown below. Find the magnitude and direction of the force exerted by the rightmost block on the middle block.



3. The crew of the Jupiter Mining Vessel *Red Dwarf* observe a GELF (Genetically Engineered Life Form) cruiser approaching at $0.7c$. Fearless superhero Ace Rimmer comes to the rescue in *Starbug*, overtaking the GELFs from behind at a speed of 0.9c relative to *Red Dwarf*. At what speed do the GELFs observe Ace approaching?

4. A spaceship, at rest, has a length of 50 m. A hangar has a length of 40 m.

   (a) How fast must the spaceship be moving relative to the hangar in order to fit inside (according to an observer standing next to the hanger)?

   (b) When traveling at the speed you determined in (a), will the pilot of the spaceship agree that the spaceship fits into the hangar? Don't just answer "yes" or "no"; support your conclusion with hard numbers.

5. A 50-kg girl stands on a scale placed on the ground. The girl holds a massless string, which she uses to swing a 3.0-kg mass around in a vertical circle of radius 60 cm at a constant rate of 0.8 rev/sec. What is the reading on the scale (in newtons) at the moment the mass is at the highest point in its path?

6. Dr. Naughty, anxious to be rid forever of his nemesis Captain Improbable, straps him into a rocket with a bomb set on a 1-year fuse, lights the fuse, and immediately launches the rocket away from Earth at a speed of $0.6c$. A camera beams back pictures of the inside of the rocket back to Earth so that Dr. Naughty can gloat over our hero's fate. Like all electromagnetic waves, the TV signals travel through outer space at speed c.

(a) How far from Earth—as measured in the Earth's reference frame—will the rocket be when the fuse completes its 1-year burn time?

(b) How long after the rocket's launch—as measured on Earth—does Dr. Naughty receive the signal showing Captain Improbable, who has gnawed through his restraints, disarming the bomb the instant before it is about to explode?

(c) Within moments of disarming the bomb, Captain Improbable rigs up his iPod to communicate with the navigation computer, turns the rocket round, and sets off back to Earth at $0.6c$. How long after his escape—as measured in the frame of the rocket—does Captain Improbable reach Dr. Naughty's hideout to settle old scores?

7. A golfer strikes a ball from ground level at an angle of 20° above the horizontal with an initial speed of 70 m/s. The ball misses the fairway and bounces off a flat road. The horizontal component of the ball's velocity is conserved during the bounce. After the bounce, the ball reaches one third of the height it reached on its first arc before landing in a sand trap. Assume that the launch point and the two landing points are all at the same elevation, and neglect air resistance.

   (a) What is the maximum height reached by the ball on its first arc?

   (b) What is the distance from the ball's launch point to the location of its bounce?

   (c) How far from the launch point does the ball hit the sand trap?

8. Typically, a car braking hard on a wet road can safely decelerate at $3.0\,\mathrm{m/s^2}$. The driver's reaction time to engage the brakes may be as great as 1.5 s. Given this information, what is the maximum speed at which cars can safely drive 60 m apart in the same lane, allowing for a worst-case scenario in which the lead car unexpectedly hits an immovable object and stops instantaneously?

9. In a circus show, a large pot (initially at rest) is dropped from a point at height h. At the same moment, a clown standing directly below throws a ball vertically upward from the ground. The ball strikes the pot head-on, smashing it into pieces and thereby saving the clown from severe concussion (or worse). At the moment of impact, the ball's speed equals that of the pot. At what height does the collision occur? Neglect air resistance.

10. Standing on the edge of the Grand Canyon, you wish to fire an arrow carrying a message to some friends, who are located on a rock outcrop located 800 m below your position and a distance 500 m away horizontally. If the arrow has an initial speed of 40 m/s, at what angle to the horizontal (specify above or below) should you launch it? Neglect air resistance.

    Hints: (1) There are two possible correct answers to this problem. (2) It may be helpful to recall the trigonometric identity $1/\cos^2 x = 1 + \tan^2 x$.