PART I: MULTIPLE CHOICE

Each multiple choice question has one best answer -- circle the letter of the best answer. **Partial credit will be given on the multiple choice questions.** If you circle two answers, one of which is correct, you will receive half credit for the question. No credit will be given for more than two answers, even if one of them is correct. Use $g = 10 \text{ m/s}^2$ throughout the exam. (4 points each for full credit)

1. A car is cruising on a highway and then hits a patch of water on the road, which slows the car down for a bit. After passing through the puddle, the car resumes its former speed. Which of the following plots reflects this motion?

   ![Graph Options]

2. Can an object's velocity change direction when its acceleration is constant?
   
   a) No, this is not possible because a constant acceleration means that it is always speeding up.
   
   b) No, this is not possible because it is always speeding up or always slowing down, but it can never turn around.
   
   c) Yes, this is possible, and a rock thrown straight up is an example.
   
   d) Yes, this is possible, and a car that starts from rest, speeds up, slows to a stop, and then backs up is an example.

3. An Olympic athlete throws a javelin at four different angles above the horizontal, each with the same speed: $30^\circ$, $40^\circ$, $60^\circ$, and $80^\circ$. Which two throws cause the javelin to land the same distance?

   a) $30^\circ$ and $80^\circ$.
   
   b) $40^\circ$ and $60^\circ$.
   
   c) $40^\circ$ and $80^\circ$.
   
   d) $30^\circ$ and $60^\circ$.

4. An object of mass $m$ is hanging by a string from the ceiling of an elevator. The elevator is moving upward, but slowing down. What is the tension in the string?

   a) Less than $mg$.
   
   b) Exactly $mg$.
   
   c) Greater than $mg$.
   
   d) Zero.
5. A stone is thrown straight up. At the top of its path, the net force acting on it is
   a) greater than its weight.
   b) greater than zero, but less than its weight.
   c) instantaneously equal to zero.
   d) equal to its weight.

6. An object slides on a level surface in the + x direction. It slows down and comes to a stop with a constant acceleration of \(-2.45\, \text{m/s}^2\). What is the coefficient of kinetic friction between the object and the floor?
   a) 0.25
   b) 0.50
   c) 4.9
   d) impossible to determine without knowing the mass of the object

7. A roller coaster car is on a track that forms a circular loop in the vertical plane. If the car is to just (barely) maintain contact with the track at the top of the loop, what would the minimum value for its centripetal acceleration be at this point?
   a) \(g\) downward
   b) \(0.5\, g\) downward
   c) \(g\) upward
   d) \(2\, g\) upward

8. The acceleration of gravity on the moon is \(1/6\) what it is on earth. The radius of the moon is \(1/4\) that of the earth. What is the moon's mass compared to the earth's?
   a) \(1/6\)
   b) \(1/16\)
   c) \(1/24\)
   d) \(1/96\)
PART II: FREE RESPONSE

9. It is a beautiful weekend day and, since winter will soon be here, you and four of your friends decide to spend it outdoors. Two of your friends just want to relax while the other two want some exercise. You need some quiet time to study for your upcoming physics test. To satisfy everyone, the group decides to spend the day on the river and split up. You stay on shore. The two people who want to relax will put a canoe in the river and just drift downstream with the 1.5 mph current. The second pair will begin at the same time as the first from 10 miles downstream. Since you have been canoeing with these people before, you know that they will have an average velocity of 2.5 mph relative to the shore when they go against this river current. They will paddle upstream until the two canoes meet. When the two canoes meet, they will come to shore and you should be there to meet them with your van. You decide to go to that spot ahead of time so you can study while you wait for your friends. Where will you wait? [17 pts]
10. You are on the target range preparing to shoot a new rifle when it occurs to you that you would like to know how fast the bullet leaves the gun (the muzzle velocity). You bring the rifle up to shoulder level and aim it horizontally at the target. Carefully you squeeze off the shot at the target which is 100. meters away. When you collect the target you find that your bullet hit 22. centimeters below where you aimed. What was the muzzle velocity? [17 pts]
11. You are planning to build a log cabin in northern Montana. You will pull the logs up a long, smooth hill to the building site by means of a rope attached to a winch. You need to buy rope for this purpose, so you need to know how strong the rope must be. Stronger ropes cost more. You know that the logs have a maximum mass of 200 kg. You measure that the hill is at an angle of 30° with respect to the horizontal, and the coefficient of kinetic friction between a log and the hill is 0.90. When pulling a log up the hill, you will make sure that the rope stays parallel to the surface of the hill and the acceleration of the log is never more than 0.80 m/s². How strong a rope should you buy? [17 pts]
12. You did so well in your physics course that you decided to try to get a summer job working in a physics laboratory at the University. You got the job as a student lab assistant in a research group investigating the ozone depletion at the Earth’s poles. This group is planning to put an atmospheric measuring device in a satellite which will pass over both poles. To collect samples of the upper atmosphere, the satellite will be in a circular orbit 200 miles (322 km) above the surface of the Earth. To adjust the instruments for the proper data taking rate, you need to calculate how many times per day the device will sample the atmosphere over the South pole. Using the inside cover of your trusty Physics text, you find that the radius of the Earth is 6.38x10³ km, the mass of the Earth is 5.98x10²⁴ kg, and the universal gravitational constant is 6.7x10⁻¹¹ N m²/kg². How many times per day should the device be programmed to sample over the South pole? [17 pts]