Points for a question are indicated in parentheses. Your solution to a question with OSE in front of it must begin with an Official Starting Equation, with the math subsequently flowing from it for full credit. If you need more space to finish a question, write and circle “BPP” at the end of the space provided and complete your work on the Back of Previous Page.

For Questions on this page, write the letter which you believe to be the best answer in the underlined space provided to the left of the question number. On subsequent pages, draw a box around your answer to each question. The expression for the final result must be in system parameters and simplified as far as possible. All information and algebraic quantities that you use to solve the problem must appear in the figure. Neglect air resistance. Calculators and notes cannot be used during the test. If you have any questions, ask the proctor.

1) (5) A boy is sitting on a scale while riding in a rollercoaster. When the rollercoaster is moving at the bottom of a circular arc, the reading on the scale will be:
   A) dependent of the rollercoaster’s mass.  
   B) less than his normal weight.  
   C) the same as his normal weight.  
   D) greater than his normal weight.

2) (5) A car’s x-component of velocity as a function of time is graphed at the right. What is the x-component of the car’s acceleration (in m/s^2)?
   A) –3  
   B) 5  
   C) –1/3  
   D) 3

3) (5) A small car of mass \( M \) collides head-on with a large truck of \( 4M \). During the collision, what is the ratio of the force magnitude \( F_{on\, car} \) exerted on the car by the truck divided by the force magnitude \( F_{on\, truck} \) exerted on the truck by the car at any instant? (that is, \( F_{on\, car} / F_{on\, truck} = \)):
   A) 4  
   B) \( \frac{1}{2} \)  
   C) 1  
   D) \( \frac{1}{4} \)

4) (5) Four forces act on an object. Two forces are directed opposite to one another. The third one is perpendicular to these two. The direction of the fourth force is different than any of the others. How many accelerations does the object experience?
   A) 1  
   B) 2  
   C) 3  
   D) 4

5) (5) You throw a steel ball straight up with some initial speed. Air resistance is negligible. When the ball has only one-fourth of its initial speed, the magnitude of its acceleration is:
   A) \( \frac{g}{4} \)  
   B) \( \frac{g}{2} \)  
   C) \( \frac{3g}{4} \)  
   D) \( g \)

6) (5) Dr. Bieniek made one small, miniscule mistake in a lecture. As a result, you deserve an easy question because you were:
   A) good  
   B) nice  
   C) attentive  
   D) asleep

Test Total =_____/180

_____/30 for this page
7. Dr. Bieniek is sitting in his car at rest on the ground at the bottom of a ramp of length $L$ inclined at angle $\theta$ to the horizontal, as shown in the diagram. He then drives up the ramp with a constant acceleration magnitude of $g/4$ and continues on, leaving the top of the ramp and enjoying a brief period of free-fall through the air.

(a)(10) Complete the diagram with all information needed to solve Part (b).

(b)(40) **OSE:** Derive an expression, in terms of relevant system parameters, for the total time that elapsed between the moment when Dr. Bieniek began to accelerate up the ramp and the moment when he reached his highest point above the ground.
8. Two blocks of masses $M$ and $3M$ are on a double frictionless incline, as shown in the diagram. The left incline makes angle $\theta$ with the horizontal, while the right incline makes angle $\phi$ with the horizontal. The blocks are connected by a massless cord that passes over a massless, frictionless pulley.

(a)(10) On the diagram, superimpose any necessary information used to complete Part (b) below.

(b)(40) OSE: Derive an expression for the acceleration of the left block of mass $M$, in terms of relevant system parameters.
9. A transparent hemispherical bowl of radius $R$ is rotating about its vertical axis at a constant rate. A small block rests on the bowl’s inside surface. Although not moving relative to the bowl’s surface, the block is carried around in a horizontal circle with the bowl’s rotation. The horizontal circle is located at angle $\theta$ up from the rotation axis, as shown in the diagram. The coefficient of static friction between the block and the bowl is $\mu$.

(a)(10) Draw a complete free-body diagram for the block using the specified coordinate axes. Add any information you use to solve Part (b) below. Remember, any algebraic quantities that you use must appear in the diagram.

(b)(40) **OSE:** Derive, in terms of relevant system parameters, an expression for the maximum speed $V$ that the block can have due to the bowl’s rotation, but still continue to move in this horizontal circle described and not slide up the side of the bowl.