Physics 211 Exam 2, Form C

Problem 1	Problem 2	Problem 3	Problem 4	Total
/25+5	/25+5	/25	/25	/100

Name: _____

Recitation section number: _____

- There are four questions worth a total of 100 points, with a possible 10 points extra credit.
- **You must show your reasoning to receive credit**. A numerical answer with no logic shown will be treated as no answer. An answer that doesn't follow from the logic shown will not be given credit, even if it is correct.
- You are highly encouraged to use both pictures and words to show your reasoning, not just algebra.
- Remember, show your reasoning as thoroughly as possible for partial credit.
- You may use $g = 10\,\mathrm{m/s^2}$ throughout, except where indicated, to minimize arithmetic.

Recitation Schedule

M003	8:25 - 9:20	Avinay	B129E
M011	8:25 - 9:20	Lindsay	106
M019	8:25 - 9:20	Francesco	HL205
M004	9:30 - 10:25	Avinay	B129E
M012	9:30 - 10:25	Julian	106
M020	9:30 - 10:25	Tie	Sims 437
M025	9:30 - 10:25	Francesco	HL205
M005	10:35 - 11:30	Avinay	B129E
M013	10:35 - 11:30	Lindsay	106
M021	10:35 - 11:30	Tie	Sims 437
M023	10:35 - 11:30	Francesco	HL205
M006	11:40 - 12:35	Andrew	B129E
M014	11:40 - 12:35	Lindsay	106
M022	11:40 - 12:35	Tie	Sims 437
M007	12:45 - 1:40	Andrew	B129E
M015	12:45 - 1:40	Kyle	106
M008	2:15 - 3:10	Andrew	B129E
M016	2:15 - 3:10	Harris	106
M009	3:45 - 4:40	Harris	B129E
M017	3:45 - 4:40	Kyle	106
M010	5:15 - 6:10	Harris	B129E
M018	5:15 - 6:10	Kyle	106

Question 1

A ball of mass m is connected by two strings to a pole, as shown, and made to rotate around it at angular velocity ω. Each string makes an angle θ with the horizontal; the radius of the ball's motion is r. The tension in the upper string is T_1, while the tension in the lower string is T_2.

a) Draw a force diagram for the ball. Indicate the coordinate system you will use for this problem next to your force diagram. (5 points)

b) Based solely on the character of its motion (i.e. without doing any mathematics), describe its acceleration vector. (5 points)

c) Relate this acceleration to the forces on the object using Newton's second law. (This will entail writing one or more equations.) (5 points)

Question 1, continued

d) Calculate T_1 and T_2 in terms of θ, r, m, and g. (5 points)

e) If ω is reduced below a certain minimum value, the ball will be unable to move as described – it will fall, with the lower string becoming slack. Find this minimum value of ω, based on your answers to part (d). (5 points extra credit)

Question 2

Two boxes sit on a table. The bottom box has mass M, and the top box has mass m. The coefficient of kinetic friction between the table and the bottom box, and between the bottom box and the top box, is μ_k.

A rope is tied to the bottom box, and a large tension T is applied horizontally. This is large enough to pull the bottom box out from under the top box.

a) Draw a force diagram for the top box and for the bottom box. (10 points each)

b) Newton's third law says that $\vec{F}_{AB} = -\vec{F}_{BA}$. Are there any pairs of forces in your diagram which form Newton's-third-law pairs? If so, list those pairs. You should ensure that your force diagrams are consistent with Newton's third law. (5 points)

Question 2, continued

d) Calculate the acceleration a_1 of the top box. (5 points)

e) Calculate the acceleration a_2 of the bottom box. (5 points extra credit)

Question 3

A person stands in a train which is traveling at speed v, looking forward. The person holds the top of a string up in the air; a stone is tied to the bottom. The train encounters a curve in the tracks, turning left; the curve has a radius of curvature r. Once the train enters the curve, the passenger will see the stone swing to the right.

a) Draw a force diagram for the stone. (5 points)

b) Calculate the angle θ that the string makes with the vertical in terms of g, v, and r. (10 points)

Question 3, continued

c) According to your force diagram, is there a force pushing the stone in the direction given by part (a)? If so, what is that force? If not, how do you explain the fact that the stone will swing to the passenger's right? (10 points)

Question 4

A large boulder of mass 300 kg sits on the surface of a frozen lake. An engineer, whose desire to see things go boom exceeds his common sense, wants to remove the boulder. He drills a hole in it, inserts a stick of dynamite, and lights the fuse. After the explosion the boulder splits into two pieces, which move in opposite directions after the collision. The larger piece has a mass $M = 200$ kg; the smaller piece has a mass $m = 100$ kg. The coefficient of kinetic friction is μ_k between both pieces and the ice; this friction eventually brings both of them to rest.

The large piece travels a distance of 20 meters after the collision before coming to rest. How far does the small piece travel? (25 points)

Hints for solving this problem:

- Calculate the relationship between the velocity of the large piece and the velocity of the small piece after the explosion. Introduce variables for these velocities.
- Calculate the relationship between the velocity of each piece after the collision and how far it travels.
- Combine the results of the preceding to figure out how far the small piece travels.