Physics 211 Exam 2, Form A

Problem 1	Problem 2	Problem 3	Problem 4	Total
/25	/25	/25	/25+10	/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.
- You are highly encouraged to use both pictures and words to show your reasoning, not just algebra.
- If you run out of room, continue your work on the back of the page.
- 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 "merry-go-round" is a large, horizontal platform free to rotate around its axis. Children can stand on top of the platform while it spins. Suppose that a merry-go-round with a radius of 3 meters is spinning, and that it rotates around its axis once every 4 seconds.

Suppose that the coefficient of kinetic friction μ_k between the children's feet and the platform is 0.4, while the coefficient of static friction μ_s between their feet and the platform is 0.5.

a) Draw a force diagram for a child standing on the platform. Indicate your choice of coordinate system. (5 points)

b) How close to the edge can a child stand to the edge without slipping? (15 points)

Question 1, continued

c) Suppose now that the children spinning the platform want to slow it down enough that their friends on top can safely walk to the edge and jump off. What is the maximum angular velocity ω that would allow a child to stand on the edge of the platform without slipping? (5 points)

Question 2

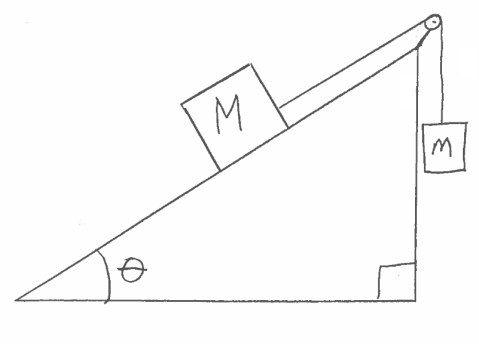
An American football player with a mass of $M = 100$ kg is running 45 degrees east of north at a speed of 5 m/s. He is tackled by another player running 60 degrees west of north at a speed of 6 m/s. After the impact, the two players are moving directly north.

a) What is the mass of the second player? (15 points)

b) How fast are they moving after the impact? (10 points)

Question 3

A book of mass M sits on an inclined plane angled at an angle θ above the horizontal;
it is connected by a string to another book of mass m hanging over the top. (See picture.)



a) In terms of M and m, what must the angle θ be such that the two books do not move? Assume for this part that there is no friction. (5 points)

Now, assume that M is large enough that it slides down the ramp. There is kinetic friction between that book and the ramp; the coefficient of kinetic friction is μ_k.

b) Draw force diagrams for both books. Indicate your choice of coordinate system for both of them (they do not have to be the same, and in fact shouldn't be!) (3 points)

Question 3, continued

c) Give a mathematical statement of Newton's second law for both books, substituting in quantities specific to this problem. (In other words, don't just write $\vec{F} = m\vec{a}$; write something useful that will help you solve the remaining parts.) (5 points)

d) What is the relationship between the acceleration of the two books? (2 points)

e) Calculate the acceleration of both books in terms of M, m, g, θ, and μ_k. (10 points)

Question 4

A person is standing in a subway car, looking forward. She is not holding onto anything, trusting the friction between her shoes and the ground to keep her balance.

Draw force diagrams for the following situations. Make sure you indicate which direction is which (i.e. tell me whether I am looking at the person from above, from the side, etc., and which direction is toward the front of the subway car.) Indicate the relative sizes of the forces by the lengths of the arrows in your force diagram. Forces that have the same magnitude should have the same size arrows; if you think it's not clear, you can write a little text telling me which forces are larger, smaller, or equal.

a) The subway car is moving forward at a constant velocity $\vec{v}$. (5 points)

b) The subway car is going over the top of a hill, and is accelerating straight downward at 3 $\mathrm{m/s^2}$*. (5 points)*

Question 4, continued

c) The subway car is moving at a constant speed v; it is turning left, gently enough that the passengers do not slip and fall. (5 points)

d) The subway car is accelerating forward at $3\,\mathrm{m/s^2}$. *(5 points)*

Question 4, continued

e) Anyone who has ridden a subway car feels themselves "thrown backwards" when it accelerates forward. What force is pushing them backwards? (If there is no such force, then explain why they feel themselves thrown backwards when the car accelerates.) (5 points)

f) Imagine now a situation that is a combination of (c) and (d); the car is accelerating forward and turning left at the same time. At a given instant in time, the car is:

- *Traveling forward at a speed v*
- *Accelerating forward at a rate a_0*
- *Turning left in a curve with a radius of curvature r*

Calculate the required coefficient of static friction μ_s between her shoes and the ground for the passenger to not slip on the floor. You will need to think carefully about what the acceleration vector of the person is. (10 points extra credit)