Final Exam 1AF21

Full Name (Printed) ______________________________

Full Name (Signature) ____________________________

Student ID Number ______________________________

- The exam is open-book and open notes. You will probably do better to limit yourself to a single page of notes you prepared well in advance.
- **All work must be your own.** You are not allowed to collaborate with anyone else, you are not allowed to discuss the exam with anyone until all the exams have been submitted (after the close of the submissions window for the exam).
- You have **120 minutes** to complete the exam and more than sufficient time to scan the exam and upload it to GradeScope. The exam *must* be uploaded to GradeScope within the time alloted (that is, by the end of the 3-hour finals slot). We will only except submissions through GradeScope and will not accept any exam submitted after the submission window closes (CAE students must contact Corbin for instructions).
- **Given the limits of GradeScope, you must fit your work for each part into the space provided.** You may work on scratch paper, but you will not be able to upload the work you do on scratch paper, so it is essential that you copy your complete solution onto the exam form for final submission. We can only consider the work you submit on your exam form.
- **For full credit the grader must be able to follow your solution from first principles to your final answer.** ***There is a valid penalty for confusing the grader.***
- It is **YOUR** responsibility to make sure the exam is scanned correctly and uploaded before the end of the submission window. The graders may refuse to grade pages that are significantly blurred, solutions to problems that are not written in the correct place, pages submitted in landscape mode and/or work that is otherwise illegible - if any of this occurs, you may not receive *any* credit for the affected parts.
- Focus on the concepts involved in the problem, the tools to be used, and the set-up. If you get these right, all that's left is algebra.
- **Have Fun!**

The following must be signed before you submit your exam:

By my signature below, I hereby certify that all of the work on this exam was my own, that I did not collaborate with anyone else, nor did I discuss the exam with anyone while I was taking it.

Signature ______________________________

EXAM 1) A drone holds station at an altitude h to observe the launch of a projectile. Upon launch, the projectile spends a time Δt above the drone and ultimately lands on a plateau of height $h/2$. The point where the projectile lands is a lateral distance D from the launch site.

- 1a) (10 points) What was the maximum height the projectile reached above the point where it was launched?

- 1b) (10 points) For how long was the projectile in motion?

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- 1c) (5 points) What were the x and y components of the projectile's velocity at launch?

- 1d) (5 points) What were the x and y components of the projectile's velocity at the point where it landed?

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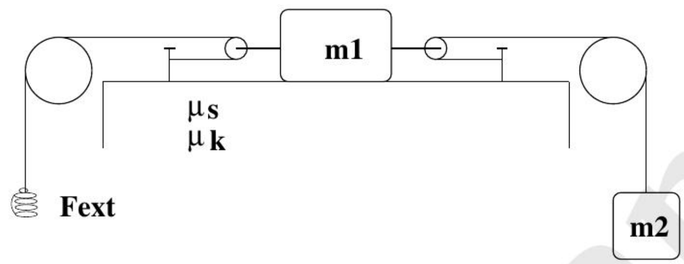

EXAM 2) Consider the system shown above. The pulleys are all massless, the blocks have masses m_1 and m_2. m_1 sits on a horizontal surface that presents kinetic and static friction characterized by the coefficients μ_k and μ_s respectively.

- 2a) (10 points) What is the minimum amount of external force that must be applied to the rope on the left in order to keep m_1 at rest?

- 2b) (5 points) What is the maximum amount of external force that can be applied to the rope on the left before m_1 will begin to slide to the left?

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- 2c) (15 points) Given a value for F_{ext} that is large enough to cause m_1 to slide to the left, find the tension in the rope that is attached to m_2 and the acceleration of m_2.

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EXAM 3) A pair of charged particles interact in such a way that they have an energy of configuration given by $U = k/r^6$, where r is the distance between the particles.

In this problem a particle of mass m_1, moving with an initial speed v_0 is traveling directly towards a very, very distant particle of mass m_2, initially at rest. The two particles are charged and interact as described above.

- 3a) (5 points) Find the force exerted on m_1 by m_2 when they are separated by a distance r. Would you expect any significant interaction when the two particles are separated by a large distance? What does that say about the potential energy when the two particles are distant?

- 3b) (10 points) If m_2 is free to move, how close will m_1 get to m_2?

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- 3c) (5 points) Compare the total kinetic energy of the masses when they were separated by a large distance to the total kinetic energy they possess when they are as close as they are going to get. Is the 'collision' elastic? Explain.

- 3d) (10 points) Find the final velocities of each of the masses when they are once again separated by a large distance.

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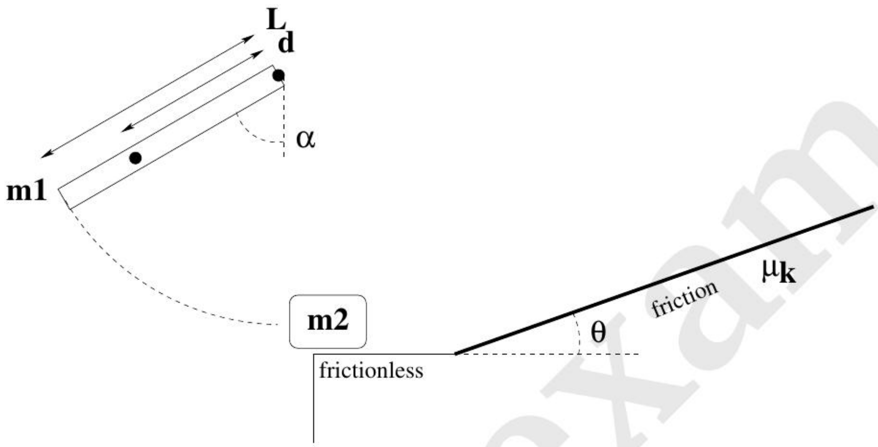

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EXAM 4) A non-uniform rod of mass m_1 and length L is attached to a pivot at one end so that it is free to swing in a vertical plane. The center-of-mass of the rod is located a distance d from the pivot and the rotational inertia about the pivot is given by I.

The rod is released at rest from an initial angular displacement with the vertical measured by α (as shown). At the very bottom of its swing, at that instant when the center-of-mass of the rod is directly below the pivot, it makes an elastic collision with a block of mass m_2 which is sitting on a horizontal frictionless surface. After the collision, the block will proceed up a very long ramp inclined at an angle θ which will present friction characterized by the coefficient μ_k.

- 4a) (10 points) With what angular velocity (measured around the pivot) was the rod traveling the instant before it hit the block?

- 4b) (15 points) With what angular velocity (measured around the pivot) will the rod rebound after the collision with the block? How fast will the block be moving immediately after the collision?

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- 4c) (5 points) What distance will the block travel up the plane?

EXAM 5) One way to do space on a budget is to launch spacecraft from an orbital platform. The initial costs to place the platform are likely to be high, but the savings with each launch *might* just make it worth the effort. For our purposes, we'll assume we've already placed an orbiting launch platform in circular orbit a distance r_1 from the center of the Earth.

- 5a) (10 points) How fast must the orbital platform move (relative to the center of the Earth) to maintain its orbit?

- 5b) (15 points) We can send a probe to the moon if we place it into an elliptical orbit which has the platform at its perigee (the point nearest the center of the Earth) and the Moon at its apogee (the point farthest from the center of the Earth). With what speed (relative to the center of the Earth) would the probe have to be launched from the platform?

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- 5c) (5 points) The idea is to save money by reducing the amount of fuel we'll have to use at launch. Should we launch the probe in the same direction the orbital platform is moving, or should we launch it in the opposite direction? Explain. Finally, find the speed with which we need to launch the probe *relative to the orbital platform.*

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