PY211 Spring 2020 Midterm Exam #2
13 April 2020

Print Name ______________________________ BU ID# _________________________

Signature ____________________________________
By signing, you agree to follow the Boston University Academic Code of Conduct for this exam.

Circle your discussion section:

D1 (W 9:05-9:55 am)	D2 (W 10:10-11:00 am)	D3 (W 11:15 am-12:05 pm)
D4 (W 12:20-1:10 pm)	D5 (W 1:25-2:15 pm)	D6 (W 2:30-3:20 pm)
D7 (W 3:35-4:25 pm)	D8 (W 6:30-7:20 pm)	D9 (Th 11:15 am-12:05 pm)
E1 (Th 12:30-1:20 pm)	E2 (Th 3:35-4:25 pm)	E3 (Th 6:30-7:20 pm)
E4 (F 8:00-8:50 am)	E5 (F 9:05-9:55 pm)	E6 (F 10:10-11:00 am)
E7 (F 11:15 am-12:05 pm)	E8 (F 12:20-1:10 pm)	E9 (F 1:25-2:15 pm)

Circle your lecture section: Suarez (9:30-10:45 am) Butler (2-3:15 pm) Mohanty (5-6:15 pm)

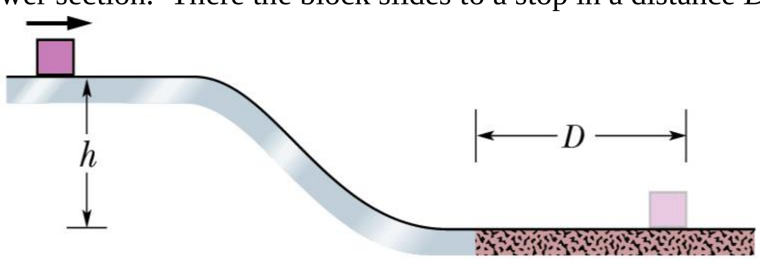
Read the following important information BEFORE starting the exam!

- You have **3 hours to complete your exam** and upload it to Gradescope after it has been downloaded.
- **Uploads after 11pm EDT will not be accepted**. You must upload a single PDF file of your exam that contains this cover page and all the problems.
- You **must show all your work** to receive any credit for each problem. The only exceptions are multiple choice problems 1.2 and 1.4. There you indicate your choice by putting an X or checkmark in the box, for example, like this: ☒.
- To ask questions during the exam, connect to the Zoom room: https://bostonu.zoom.us/j/250221309?pwd=OUI4RFlVN1kvUHNDN3ZQSTR2NExSZz09 the password is **py211MT2**. You will initially be in a waiting room until the proctor brings you in to ask your question. Note that the chat is only enabled with an instructor.
- You are expected to adhere to the University's Academic Code of Conduct. All the work on this exam must yours and yours alone.
- The exam is "open-book". You may consult your notes and other course material. Communication with other people about the exam or consulting sources beyond your notes and other course material is **strictly prohibited**.

Problem 1 [20 points]

1.1 [4 pts] You lift a book from the floor and set it on your desk. It is initially at rest and ends up at rest, so $\Delta K = 0$. Yet you have certainly done work on the book. Explain why this does not violate the work-energy theorem.

1.2 [6 pts] A block slides along a track that descends a distance *h*. The track is frictionless except for the lower section. There the block slides to a stop in a distance *D*.



(i) If we decrease *h*, the block stops in a distance that is (select one)

☐ Longer than *D* ☐ Shorter than *D* ☐ Equal to *D*

(ii) If, instead, we increase the mass of the block, the stopping distance will be (select one)

☐ Longer than *D* ☐ Shorter than *D* ☐ Equal to *D*

1.3 [6 pts] Consider the collision of two objects where one object is initially at rest.

(i) Is it possible for both objects to be at rest after the collision? If yes, provide an example. If no, explain why not.

(ii) Is it possible for one of the objects to be at rest after the collision? If yes, provide an example. If no, explain why not.

1.4 [4 pts] Two disks with different radii r_1 and r_2, where $r_1 > r_2$, are free to spin separately about an axis through the center of each disk. Both disks start from rest, and both undergo the same constant angular acceleration for the same length of time. Which disk will have the larger final angular velocity? (select one)

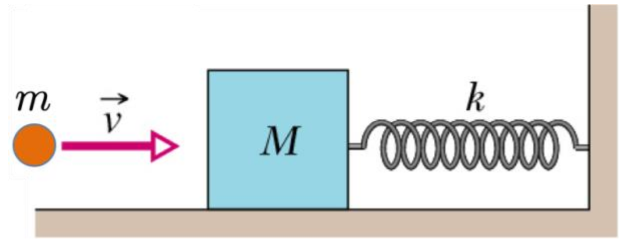
☐ Disk 1

☐ Disk 2

☐ The disks will have the same final angular velocity

☐ The answer depends on the mass of the disks

Problem 2 [13 points]



A block of mass M, at rest on a horizontal frictionless table, is attached to a wall by a massless spring whose spring constant is k. A blob of putty of mass m and velocity $\vec{v}$ hits the block and remains stuck to the block.

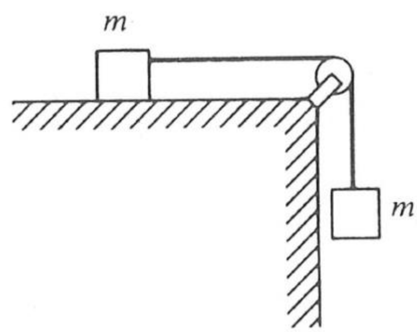
2.1 [3 pts] Is the putty-block collision elastic or inelastic? Explain.

2.2 [4 pts] Calculate the speed of the block immediately after the collision.

2.3 [6 pts] Calculate the maximum amount the spring is compressed after the collision.

Problem 3 [14 points]

Two mass m blocks are connected by a massless string that passes over a pulley, as shown. The pulley is a uniform cylinder with mass m and radius R, and the pulley's axle is frictionless. The string does not slip on the pulley. The coefficient of kinetic friction between the block and the horizontal surface is μ. The system is released from rest.



3.1 [3 points] Is mechanical energy conserved as the blocks move? Explain.

3.2 [3 points] Find the moment of inertia of the pulley.

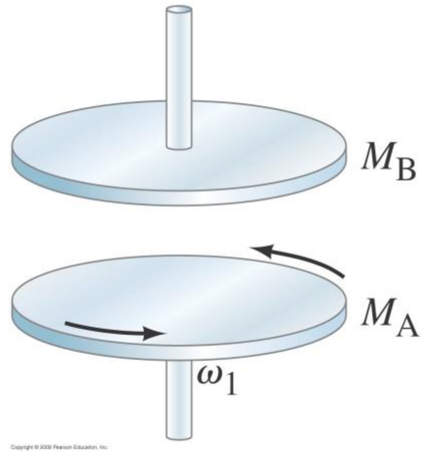
3.3 [8 points] Calculate the speed of the blocks after they have moved a distance d. Your answer must be in terms of d, g and μ only, your answer should not depend on m or R.

Problem 4 [6 points]

A thin, uniform rod is bent into a square with sides of length L. If the total mass of the rod is M, calculate its moment of inertia about an axis through the center of the square and perpendicular to the plane of the square.

Problem 5 [11 points]

A simple clutch system consists of two uniform cylindrical plates, *A* and *B,* that can be pressed together. Each plate is connected to an axle whose mass we can neglect. The two plates have masses M_A and M_B and have equal radii R_0. They are initially separated as shown. Plate M_A is spun up from rest by constant angular acceleration to an angular velocity ω_1 in a time t_1.

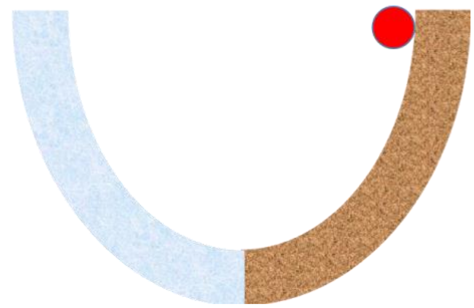


5.1 [3 pts] Calculate the angular momentum of the plate *A* once its angular velocity has reached ω_1.

5.2 [4 pts] Calculate the torque required to accelerate plate A from rest to ω_1.

5.3 [4 pts] Next, plate B, initially at rest but free to rotate without friction, is placed in firm contact with freely rotating plate A. The two plates then rotate together at a constant angular velocity ω_2. Calculate ω_2 in terms of ω_1, M_A and M_B, your answer should not depend on R_0.

Problem 6 [9 points]



A uniform solid ball travels along the U-shaped track shown in the figure. The ball starts on the right-hand side of the track where it is released from rest at a height *h* above the track's lowest point. There is friction on the right-hand side of the track so that the ball rolls there without slipping. The left-hand side of the track is frictionless. You may assume that *h* is much larger than the radius of the ball.

6.1 [5 points] Calculate the speed of the ball's center of mass at the lowest point of the track.

6.2 [4 points] Calculate the ball's maximum height H above the track's lowest point when the ball is on the left-hand side of the track.