Name:______________________________ ID:______________________________

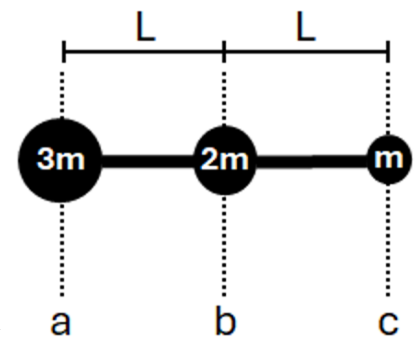
Physics 202

Midterm 1

1/29/2025

Collaboration is not allowed. Allowed on your desk are: ten 8.5 x 11 inch doubled sided sheets of notes that are bound together, non-communicating graphing scientific calculator, a page of scratch paper, writing utensils, and the exam. You will have 80 minutes to complete this exam.

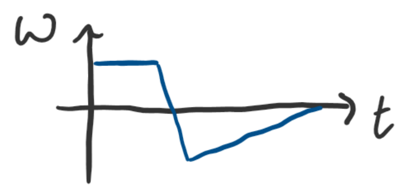
For questions 1 through 4 **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **7** correct answers in this section and only the first **7** filled in answers will be graded. There is no partial credit.



1. From left to right, three masses of mass 3m, 2m, and m are connected in a straight line by rigid, massless rods. The distance between the 3m and 2m mass is L. The distance between the 2m and m mass is also L. Three potential axes of rotation are depicted, each are vertical lines, centered on the masses, labeled respectively from left to right, a, b, and c. You may assume L is much larger than the radius of the masses.

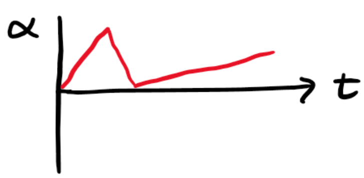
Around which of the axes would this system have the greatest moment of inertia? □ (a) axis a □ (b) axis b □ (c) axis c	Around which of the axes would this system have the smallest moment of inertia? □ (d) axis a □ (e) axis b □ (f) axis c

2. The angular velocity (ω) as a function of time for a rotating object is plotted to the right.

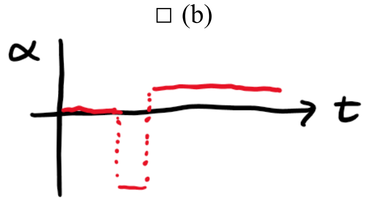


Which of the following angular acceleration (α) as a function of time plot(s) best represent the same motion?

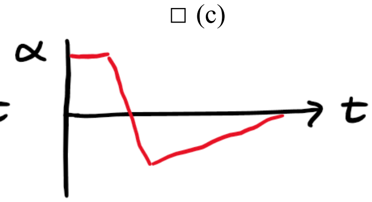
□ (a)



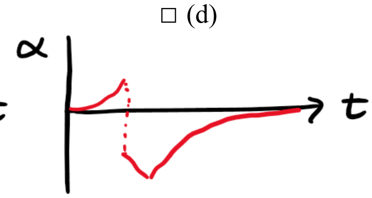
□ (b)



□ (c)

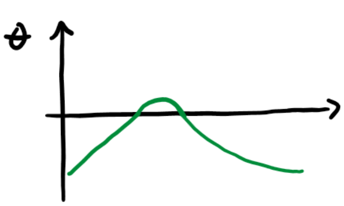


□ (d)

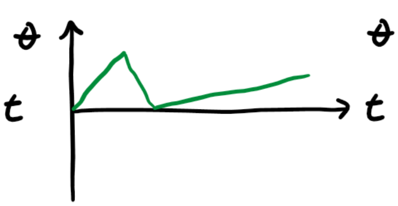


3. Consider the angular velocity plot from the previous question. Which of the following angular position (θ) plot(s) best represent the same motion?

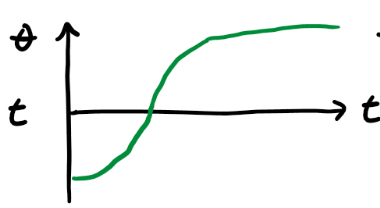
□ (a)



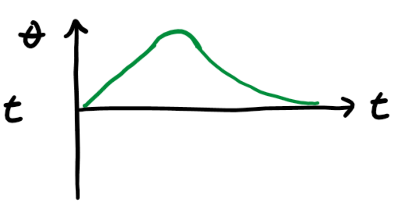
□ (b)



□ (c)



□ (d)



4. Referring to the scenario in next question (question number 5), which of the following are true statements as the cat is accelerating to the ground holding the wire:

- □ (a) The magnitude of the tension in the wire is **less than** the weight of the cat
- □ (b) The magnitude of the tension in the wire is **equal to** the weight of the cat
- □ (c) The magnitude of the tension in the wire is **greater than** the weight of the cat
- □ (d) The magnitude of the tension in the wire cannot be compared to the weight of the cat because the quantities have different units and dimensions
- □ (e) The cat's acceleration is equal to g
- □ (f) The cat's acceleration is less than g

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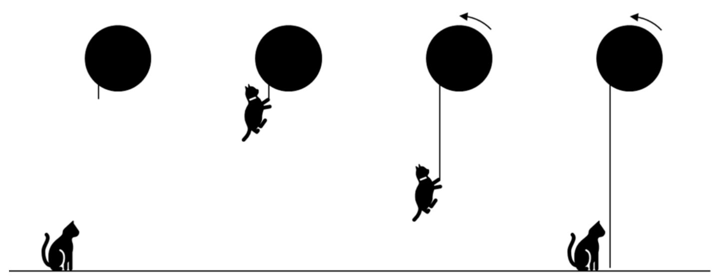
5. (6 points) A certain physics instructor's fancy new 3D printer came with a spool of plastic wire. While setting up the printer, the instructor left the spool of wire hanging on a rod. The instructor's curious cat jumped up, grabbing onto the loose wire, then accelerated back down to the ground holding the wire. As they fell, the wire spool unwound.

Assumptions: the plastic wire is massless and flexible, the spool itself has a large mass. The system includes the cat, earth, the ground, the spool, and the wire.



Four snapshots are illustrated in the image.

Snapshot 1: When the cat is on the ground, before it jumps

Snapshot 2: When the cat is at the top of its jump, as it grabs the wire

Snapshot 3: When the cat is falling, holding onto the wire

Snapshot 4: A few seconds after the cat has landed.

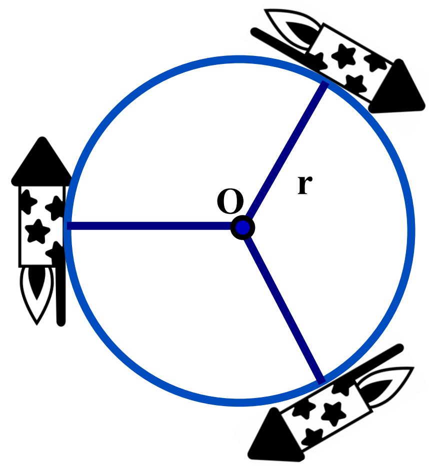
Identify the energy transformations (from one form of energy to another) which occur:

(a) between snapshot 1 and 2

(b) between snapshot 2 and 3

(c) between snapshot 3 and 4

6. (12 points) A festive firework consists of three rockets oriented around a wheel of radius **r**. The wheel is of negligible mass and is fixed at its center, able to rotate freely. When the rockets fire this spins the wheel. Each rocket has a mass of **m**, and provides a thrust of $\mathbf{F^{th}}$ tangent to the wheel for a time interval $\mathbf{\Delta t}$. Treat each rocket as a point particle with a moment of inertia mr^2 around the axis O. Answer each question symbolically ***only*** in terms of some or all of the quantities given: $\mathbf{\Delta t}$, **m**, **r**, and $\mathbf{F^{th}}$. You can assume the net torque around axis O from gravity is zero and the rockets start from rest.



(a) Find an expression for the magnitude of the angular acceleration of the rocket around axis O.

(b) What is the magnitude of the tangential acceleration of the rockets during the firing stage?

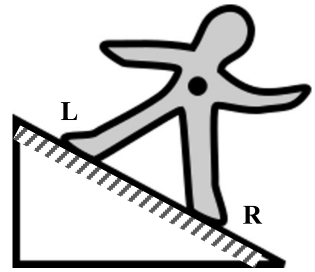
(c) Find an expression for the magnitude of the final angular velocity around axis O.

(d) What is the final translational speed of one of the rockets?

(e) What is the magnitude of the radial component of the translational acceleration of the rockets at the end of the firing stage?

(f) Use dimensional analysis sensemaking by checking that the units or dimensions of your answer to part (e) are the same as the units or dimensions of translational acceleration.

7. (12 points) A hiker is in the process of climbing a steep mountain when they decide to take a short rest while standing. The hiker finds it easiest to keep from tipping over if they stand as shown in the figure, with their left foot higher up the mountain than their right foot. The dot in the picture represents the hiker's center of mass. The hiker is not moving due to friction.



(a) In the provided table, identify the correct description of both the translational and rotational motion of the hiker.

(b) Sketch and label an extended free body diagram for the hiker using an axis about the hiker's center of mass.

Translational	Rotational
static equilibrium	static equilibrium
dynamic equilibrium	dynamic equilibrium
dynamics	dynamics

(c) Indicate the direction of the torque on the hiker due to the forces of friction on the left and right foot separately.

(d) Is the magnitude of the normal force on the hiker's left foot (toward the top of the mountain) *greater than, less than,* or *equal to* the magnitude of the normal force on the hiker's right foot (toward the bottom of the mountain)? Explain your reasoning using you diagram and the physics principles we discussed in class.

(e) Give an explanation for why the hiker would find it more challenging to stand with their two feet close together.