APPC, Mechanics: Unit γ HW 5

Name: ____________________________________
Hr: ___ Due at beg of hr on: ___________

Uγ, HW5, P1
Reference Video: "Angular Momentum" YouTube, lasseviren1, ROTATIONAL MOTION playlist

A. "The net force on an object (or system) is the time-derivative of the object's (or system's) momentum."
Write the calculus-type equation for the previous statement. Use vector symbols, where necessary.

B. From your Part A answer, we see that: If the net force equals zero, then the object's (or system's) momentum RIGHT NOW must compare how...to its momentum, say, later on?

C. The rotational analog of Part A's opening statement is... "The net ___________ on an object (or system) is the time-derivative of the object's (or system's) ______________ ___________________."

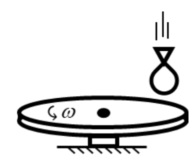
D. Write the calculus equation for your Part C answer. Use vector symbols, where necessary.

E. Use words to write a statement of the rotational analog for ALL of Part B that follows the colon (:) in that question, i.e., not only the rest of Part B's question, but also Part B's answer.

F. At right, write the expanded form of the angular momentum equation. HINT: Your answer should have two 'equals' signs, four vector symbols, and one cross product.

G. To review: What does the narrator mean when he uses the term "prime", i.e., the symbol ' ?

A heavy sandbag is about to strike a rotating platform, as shown in the figure.



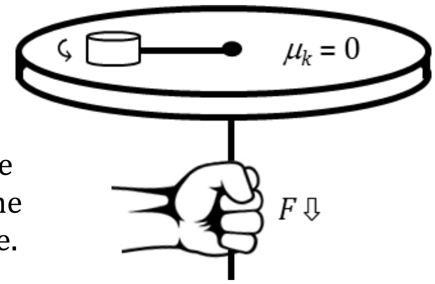
H. At impact, CIRCLE the direction of the horizontal force on the... platform: ⊗ ⊙
sandbag: ⊗ ⊙

I. Why will the forces in your Part H answers NOT exert a net torque on the platform/sandbag system?

J. For each set of conditions below, circle TWO of the four variables. A large variable indicates a large magnitude for that quantity; a small variable indicates a small magnitude for that quantity.

	INITIAL	FINAL
i. Diver, in the air...	limbs close to torso, spinning quickly I I ω ω	limbs entended, to enter the water I I ω ω
ii. Rotating star...	normal form, shining brightly I I ω ω	collapsed into a dense neutron star I I ω ω
iii. Spinning ice skater...	arms stretched out horizontally I I ω ω	arms brought in, close to body I I ω ω
iv. Platform, Parts H-I...	before sandbag hits platform I I ω ω	after sandbag hits platform I I ω ω

Uγ, HW5, P2
Reference Video: "Angular Momentum (Part II)"
YouTube, lasseviren1, ROTATIONAL MOTION playlist



The figure shows a puck attached to a string that passes through a hole at the center of a frictionless table. Initially, a person holds the string lightly, and the puck travels in a large circle. Then, the person pulls down harder on the rope.

A. What happens to the radius of the puck's motion when the person pulls harder?

B. When the person pulls harder, does this exert a torque on the puck? Explain your answer.

C. Based on your Part A answer, how must the rotational inertia of the puck change?

D. Based on your Part C answer and your previous work (see HW5, P1, Part J), how will the puck's angular velocity change?

E. What fundamental law or principle of physics led you to your Part D answer?

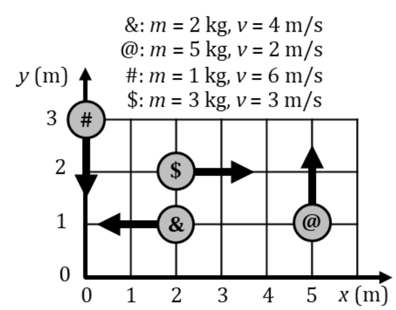
F. Go back to your Part A answer. Based on that...Was work done by the person on the puck?

G. Based on your Part F answer, what must happen to the puck's kinetic energy?

H. What fundamental law or principle of physics led you to your Part G answer?

The key point of the next part of the video is that ANY moving mass can be considered to have an angular momentum about ANY random point, via the equation $\vec{L} = \vec{r} \times \vec{p} = r_{\perp} mv$.

I. The masses shown are moving in straight lines on an *x*-*y* grid system. Determine the $\vec{L}$ of each mass, about the origin, as well as the total $\vec{L}$ of all the masses put together. Note that there is NO circular motion; nonetheless, we can calculate each mass's angular momentum with respect to any chosen point; here, the origin. Put proper units on your answers, and specify each angular momentum as being CW or CCW.



i. $\vec{L}_{\&} =$

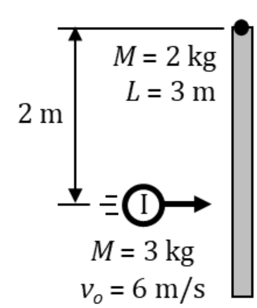
iii. $\vec{L}_{\#} =$

ii. $\vec{L}_{@} =$

iv. $\vec{L}_{\$} =$

v. $\vec{L}_{total} =$

The figure shows a rod, pinned at one end. A mass of clay approaches the rod. When the two collide, the clay will stick to the rod and the combined mass will begin to rotate.



J. Determine the kinetic energy of the clay-rod system, prior to impact.

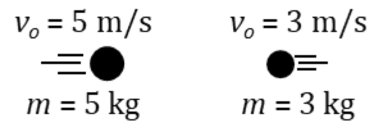
K. State the type of collision that occurs.

L. Following the example in the video, determine the angular speed the combined mass will have, immediately after impact.

M. Use your Parts J and L answers to determine the thermal energy released during the collision.

Uγ, HW5, P3

Reference Videos: (1) “Review of Momentum (Part I)”
(2) “Review of Momentum and Impulse (Part II)”
YouTube, lasseviren1, MOMENTUM playlist



A. The masses shown collide and stick. Determine:

i. the final velocity of the two-mass system

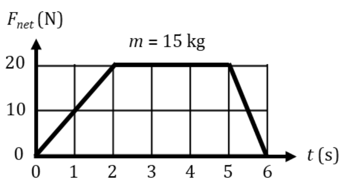
ii. the impulse of the 5 kg mass on the 3 kg mass

iii. the impulse of the 3 kg mass on the 5 kg mass

iv. If the time of impact (before a common velocity is reached) is 0.5 s, find the average force the 5 kg mass exerts on the 3 kg mass over that time.

v. Based on your Part Aiv answer, find the average force the 3 kg mass exerts on the 5 kg mass over the same time.

B.



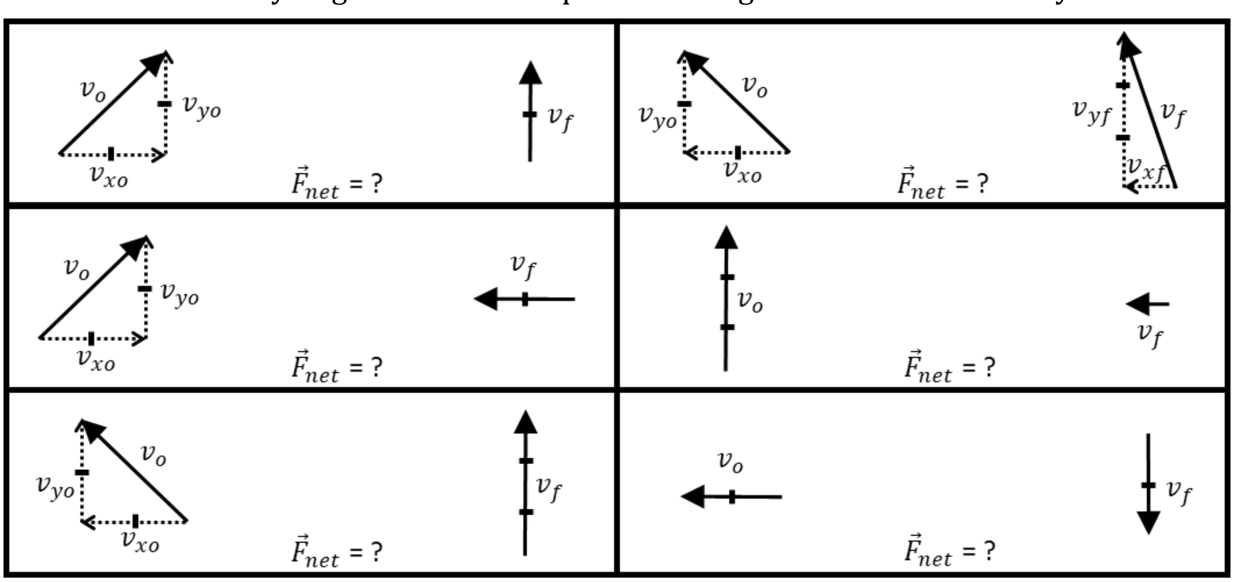
If the initial velocity is −2 m/s, find the final velocity.

C. A 2 kg mass has the momentum-time function $p(t) = 2t^3 - 4t^2 - 2t + 5$. Determine the:

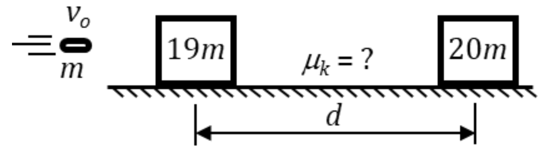
i. net force on the mass at t = 2 s

ii. acceleration of the mass at t = 2 s

D. Initial and final velocity vectors are shown below. For each scenario, <u>draw a vector to show the direction of the net force that must have acted</u>. x- and y-velocity components are shown as dashed arrows. The tick-marks on the vectors give you an idea of a vector’s magnitude; basically, either one, two, or three units of magnitude. It may be helpful to lightly sketch plausible components of each net force vector and then Pythagorize these components using a darker line to show your final answer.



Uγ, HW5, P4
Reference Video: "Review of Momentum and Impulse (Part III)"
YouTube, lasseviren1, MOMENTUM playlist



A. The figure shows a bullet (mass m) heading toward a block (mass $19m$) at a known speed v_o. After the bullet embeds in the block, the combined mass slides along a horizontal surface a distance d before stopping. Your ultimate goal is to derive an expression for the surface's coefficient of friction μ_k.

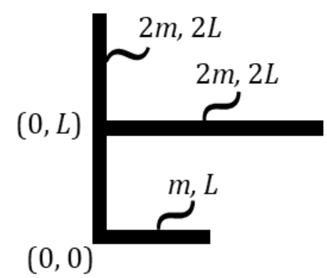
i. In terms of v_o, determine the speed of the combined mass v_{comb} immediately after the collision.

ii. State which conservation law you used in Part Ai. Also, explain WHAT IT WAS about the physical situation that prompted you to use this particular law at this particular point in the analysis.

iii. State which conservation law you DIDN'T use in Part Ai, and tell why you DIDN'T use it.

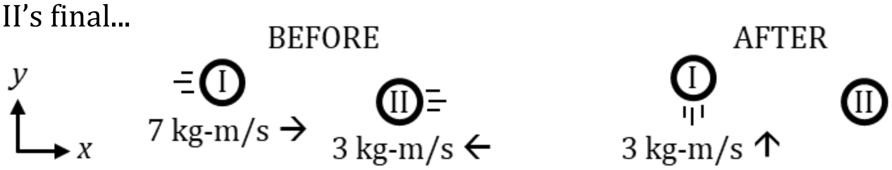
iv. Use your Part Ai answer, a fundamental constant, and given quantities to find an expression for μ_k.

B. The object shown consists of three straight, connected bars: one of length L (and mass m) and the other two of length $2L$ (and mass $2m$). One corner of the object is situated at the origin; one other coordinate is also given. The mass of each bar is uniformly distributed. Determine the coordinates of the object's center of mass, i.e., determine its x_{com} and its y_{com}. HINT: Recall that any center-of-mass equation has the basic form: $z_{com} = \frac{1}{m_{tot}}(m_1 z_1 + m_2 z_2 + \cdots)$.



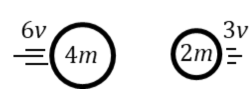
C. Two objects, I and II (not necessarily of equal mass), approach each other, collide, and bounce off. Determine Object II's final...

i. x-momentum
ii. y-momentum
iii. total momentum



Document your answers by drawing arrows on Object II in the AFTER depiction. Label the three arrows with quantitative values. Also, draw in and label the angle of the total momentum.

D. Use the general form of any center-of-mass equation shown in Part B to determine the velocity of the center of mass, i.e., the v_{com}, of the two-object system shown.



E. Suppose the objects of Part D collide in a perfectly inelastic collision. Use the conservation of momentum to show that the system's v_{com} remains unchanged, after the collision.

F. In Part E, the objects DO exert forces on each other. Explain, then, why the v_{com} remains unchanged...?

Uγ, HW5, P5

Reference Videos: (1) "Rotational Motion Review (Part I)"
(2) "Rotational Motion Review (Part II)"
YouTube, lasseviren1, ROTATIONAL MOTION playlist

A. An object rotates according to: $\theta(t) = 3t^3 + 4t^2 + 5t + 6$. At t = 1 s, determine the object's:

i. angular velocity ii. angular acceleration

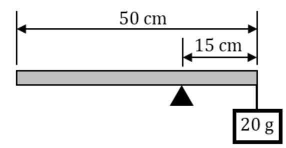
B. If the Part A object is a uniform cylinder rotating about its central axis (M = 2 kg, R = 1 m) find the:

i. net torque acting on the cylinder at t = 1 s

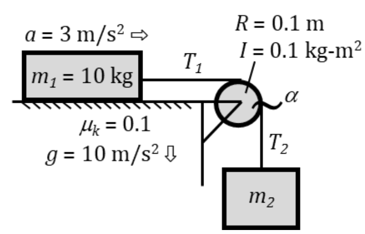
ii. rotational kinetic energy of the cylinder at t = 1 s

iii. angular momentum of the cylinder at t = 1 s

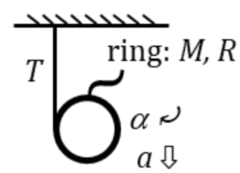
C. The figure shows a system consisting of a uniform rod and a 20-gram mass that is balancing on a pivot. Determine the rod's mass, in grams.



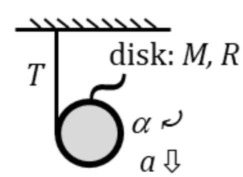
D. Using the figure at right, determine T_1, α, T_2, and m_2.



E. A thin ring is suspended from the ceiling with a string that is wound around the ring. The ring is released from rest. By writing three equations with three unknows, determine T, a, and α, in terms of M, R, and the fundamental constant g.



F. Repeat your work of Part E, but this time you have a uniform disk instead of a ring.



G. Based on your Parts E and F answers, CIRCLE the correct answers below. In which case...

i. ...would the object hit the floor first?	RING	DISK	IT'S A TIE
ii. ...would the string be more likely to snap?	RING	DISK	IT'S A TIE
iii. ...is there a larger net force on the object?	RING	DISK	IT'S A TIE
iv. ...is there a larger net torque on the object, about its *com*?	RING	DISK	IT'S A TIE