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khactam001@e.ntu.edu.sg
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← 24S1-PH1011-PHYSICS, Fall 2024

OA7: Rotational Dynamics (Homework)

INSTRUCTOR
Meng Lee Leek
Nanyang Technological University

Current Score

QUESTION	1	2	3	4	5	6	7	8	9
POINTS	–/9	–/3	–/30	–/24	–/12	–/9	–/18	–/3	–/15

TOTAL SCORE

–/123 | 0.0%

Due Date

SUN, OCT 20, 2024
11:59 PM GMT+8

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Assignment Submission & Scoring

Assignment Submission

For this assignment, you submit answers by question parts. The number of submissions remaining for each question part only changes if you submit or change the answer.

Assignment Scoring

Your last submission is used for your score.

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1. **[–/9 Points]** DETAILS MY NOTES **SERPSE10 11.A.OP.021.**

ASK YOUR TEACHER PRACTICE ANOTHER

The top edge of a thin rectangular metal plate with a mass of 2.80 kg is attached to a horizontal rod parallel to the edge of the plate. The plate hangs from this rod and is free to rotate about it without friction. The vertical height of the plate is 40.0 cm. The plate is pulled to the right until it makes an angle of 28.0° from vertical and then released from rest. At the same time, a piece of clay is tossed at the plate, moving to the right. At the moment the plate reaches vertical, moving left, it collides with the clay. The piece of clay strikes the plate at its bottom edge, moving to the right perpendicular to the plate at the moment of impact. Its mass is 330 g and its speed just before impact is 150 cm/s. The clay sticks to the plate after impact.

(a) What is the angular speed (in rad/s) of the plate the instant before it collides with the clay? (Round your answer to at least two decimal places.)

[ ] rad/s

(b) What is the angular speed (in rad/s) of the plate-clay system immediately after the collision?

[ ] rad/s

(c) What is the magnitude of the maximum angular displacement from the vertical (in degrees) that the plate-clay system will reach after the collision?

[ ] °

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2. **[–/3 Points]** DETAILS MY NOTES **SERPSE10 11.A.OP.024.**

ASK YOUR TEACHER PRACTICE ANOTHER

A diver with a mass of 54.0 kg is rotating head-over-heels in mid-air, at an angular speed of 2.00 revolutions per second, in a tucked position (that is, with arms, legs, and head pulled into a tight ball). In this position, the diver can be modeled as a solid sphere with a radius of 0.550 m, rotating about its center. Just before landing, while still in the air, the diver fully extends her arms and legs. In this position, she can be modeled as a long, thin rod, with a length of 1.90 m, the distance from her feet to her fingertips. The rod rotates about the center, with the axis of rotation perpendicular to the length of the rod.

What is her angular speed (in revolutions per second) with her arms and legs fully extended?

[ ] rev/s

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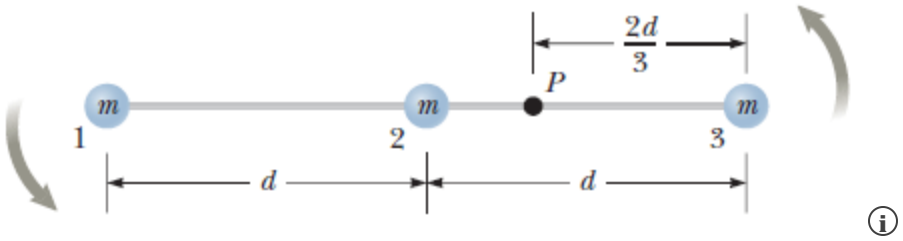
3. [–/30 Points] DETAILS MY NOTES SERPSE10 11.A.OP.026.

ASK YOUR TEACHER

A stiff, thin, metal rod with negligible mass is free to rotate in a vertical plane about pivot point *P*, as shown in the figure below. The rod has three small beads (labeled 1, 2, and 3 in the figure), all with the same mass *m*, attached to it as shown. The rod is held horizontally and then released from rest at time $t = 0$. Find all results below in terms of the mass *m*, distance *d*, and acceleration due to gravity *g*.



(a) What is the moment of inertia of the system of three particles about the pivot point *P*?

$I =$

(b) What is the net torque magnitude about point *P* at $t = 0$?

$\tau_{net} =$

(c) What is the angular acceleration of the system about point *P* at $t = 0$?

magnitude $\alpha =$

direction ---Select---

(d) What is the linear acceleration of bead 3 at $t = 0$?

magnitude $a =$

direction ---Select---

(e) What is the maximum kinetic energy of the system?

K_{max} =

(f) What is the maximum angular speed about point *P* attained by the rod?

ω_{max} =

(g) What is the maximum angular momentum of the system about point *P*? (Enter the magnitude.)

L_{max} =

(h) What is the maximum speed attained by bead 2?

v_{max} =

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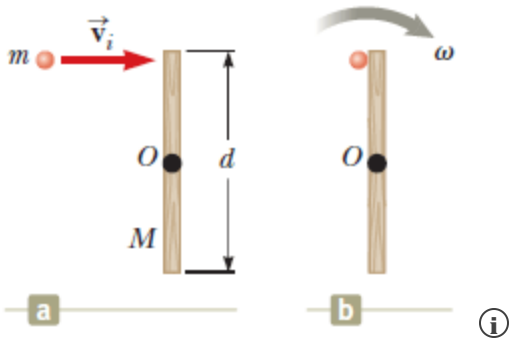
4. [–/24 Points] DETAILS MY NOTES SERPSE10 11.A.OP.027.

ASK YOUR TEACHER PRACTICE ANOTHER

A small wad of clay with a mass m is moving to the right at speed v_i, as show in figure (a) below, when it strikes the edge of a thin rod.



The rod, which has a mass M and length d, is initially at rest and is free to pivot around a mostly frictionless axle through its center and perpendicular to the page at point O. The clay projectile sticks to the rod and the rod begins to rotate at an angular speed ω, as shown in figure (b).

(a) We wish to find the angular momentum and fractional change in kinetic energy after the collision. What is the appropriate analysis model to use in order to do this?

- ○ isolated system
- ○ non-isolated system

(For the following, use the following as necessary: m, v_i, M, and d.)

(b) What is the magnitude of the angular momentum of the system before the collision about an axis through O?

L_{total} =

(c) What is the moment of inertia of the system about an axis through O after the projectile sticks to the rod?

I_{total} =

(d) What is the angular speed ω after the collision (in terms of the given quantities)?

ω =

(e) What is the kinetic energy of the system before the collision?

K_i =

(f) What is the kinetic energy of the system after the collision?

K_f =

(g) What is the magnitude of the fractional change of kinetic energy of the system due to the collision?

$\left|\frac{\Delta K}{K_i}\right|$ =

(h) **What If?** What would the fractional change of kinetic energy of the system be if, instead of sticking to the end of the rod, the projectile continued its motion in the horizontal direction with a speed $\frac{v_i}{2}$ after the collision? (Assume $m < M$.)

$\left|\frac{\Delta K}{K_i}\right|$ =

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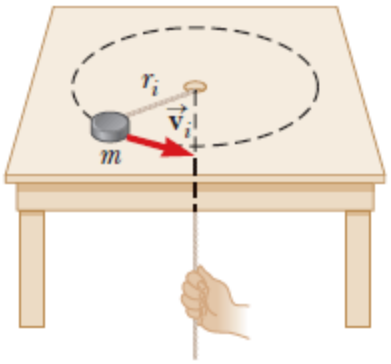
5. [–/12 Points] DETAILS MY NOTES SERPSE10 11.A.OP.029.

ASK YOUR TEACHER

A disk of mass m is attached to a lightweight, taut string which keeps it in circular motion, as shown in the figure below.



The disk slides on a horizontal table with negligible friction at speed v_i, and the radius of its circular path is r_i. The string passes through a small hole in the table and is initially held in place. The string is then slowly pulled downward so that the radius of the circular path decreases to r. (Unless otherwise stated, use the following as necessary: m, v_i, r_i, and r.)

(a) What is the speed of the disk when the radius is r?

v =

(b) What is the tension in the string when the radius is r?

T =

(c) How much work is done by the hand as it pulls the string downward to decrease the radius of the circular path from r_i to r?

W =

(d) **What If?** If the string rubs against the side of the hole as it is pulled, so that a constant frictional torque of magnitude τ is exerted on the system, what is the final speed of the puck if it takes time t for the string to be pulled? (Use the following as necessary: m, v_i, r_i, r, τ, and t.)

$v_f =$

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6. **[–/9 Points]** DETAILS MY NOTES **SERPSE10 11.A.P.033.**

ASK YOUR TEACHER PRACTICE ANOTHER

A thin, uniform, rectangular sign hangs vertically above the door of a shop. The sign is hinged to a stationary horizontal rod along its top edge. The mass of the sign is 2.40 kg and its vertical dimension is 55.0 cm. The sign is swinging without friction, becoming a tempting target for children armed with snowballs. The maximum angular displacement of the sign is 25.0° on both sides of the vertical. At a moment when the sign is vertical and moving to the left, a snowball of mass 570 g, traveling horizontally with a velocity of 160 cm/s to the right, strikes perpendicularly the lower edge of the sign and sticks there. (Due to the nature of this problem, do not use rounded intermediate values—including answers submitted in WebAssign—in your calculations.)

(a) Calculate the angular speed of the sign immediately before the impact.

rad/s

(b) Calculate its angular speed immediately after the impact.

rad/s

(c) The spattered sign will swing up through what maximum angle?

°

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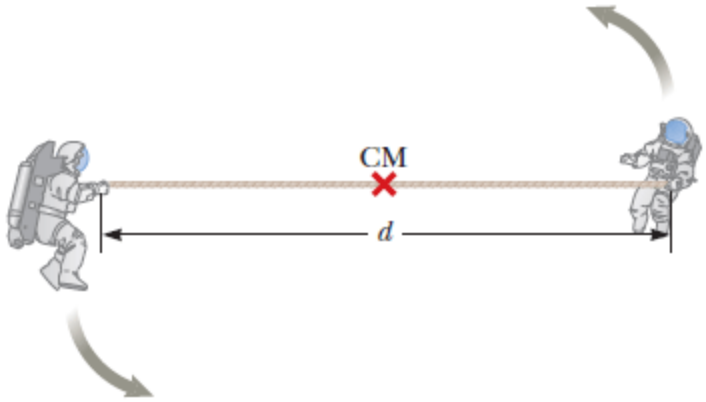
7. **[–/18 Points]** DETAILS MY NOTES **SERPSE10 11.A.P.040.**

ASK YOUR TEACHER PRACTICE ANOTHER

Two astronauts, each having a mass M, are connected by a rope of length d having negligible mass. They are isolated in space, orbiting their center of mass at speeds v. (Use any variable or symbol stated above as necessary.)



(a) Treating the astronauts as particles, calculate the magnitude of the angular momentum of the two-astronaut system.

L_i =

(b) Calculate the rotational energy of the system.

K =

By pulling on the rope, one of the astronauts shortens the distance between them to $d/11$.

(c) What is the new angular momentum of the system?

L_f =

(d) What are the astronauts' new speeds?

v_f =

(e) What is the new rotational energy of the system?

K_f =

(f) How much chemical potential energy in the body of the astronaut was converted to mechanical energy in the system when he shortened the rope?

W =

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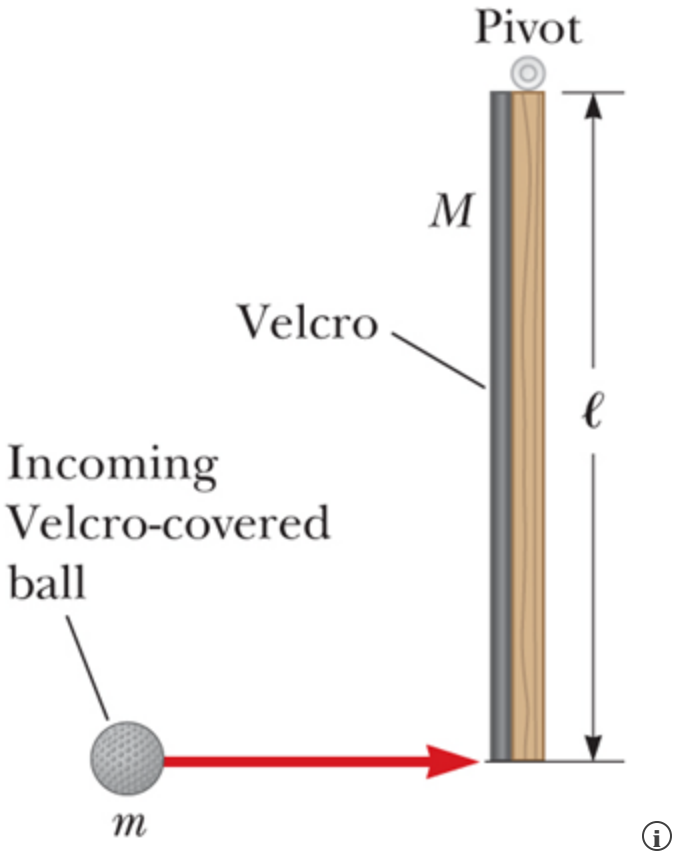
8. [–/3 Points] DETAILS MY NOTES SERPSE10 11.A.P.043.CTX.

ASK YOUR TEACHER PRACTICE ANOTHER

You are attending a county fair with your friend from your physics class. While walking around the fairgrounds, you discover a new game of skill. A thin rod of mass M = 0.575 kg and length ℓ = 2.40 m hangs from a friction-free pivot at its upper end as shown in the figure.



The front surface of the rod is covered with Velcro. You are to throw a Velcro-covered ball of mass m = 1.45 kg at the rod in an attempt to make it swing backward and rotate all the way across the top. The ball must stick to the rod at all times after striking it. If you cause the rod to rotate over the top position (that is, rotate 180° opposite of its starting position), you win a stuffed animal. Your friend volunteers to try his luck. He feels that the most torque would be applied to the rod by striking it at its lowest end. While he prepares to aim at the lowest point on the rod, you calculate how fast he must throw the ball to win the stuffed animal with this technique. How fast must he throw the ball to win the stuffed animal? (Enter the minimum speed necessary to win in m/s.)

m/s

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9. **[–/15 Points]** DETAILS MY NOTES **SERPSE10 11.A.P.044.**

ASK YOUR TEACHER PRACTICE ANOTHER

A uniform rod of mass 349 g and length 50.0 cm rotates in a horizontal plane about a fixed, vertical, frictionless pin through its center. Two small, dense beads, each of mass m, are mounted on the rod so that they can slide without friction along its length. Initially the beads are held by catches at positions 10 cm on each side of center, and the system is rotating at an angular speed of 35.0 rad/s. The catches are released simultaneously, and the small beads slide outward along the rod.

(a) Find an expression for the angular speed ω_f of the system at the instant the beads slide off the ends of the rod as it depends on m.

ω_f =

rad/s

(b) What are the maximum and the minimum possible values for ω_f and the values of m to which they correspond?

$\omega_{f\,max}$ = rad/s

when m = ---Select---

$\omega_{f\,min}$ = rad/s

when m = ---Select---

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