

Sample exam problems

Attached here is a set of sample exam questions from past terms in the course. These problems were chosen from past terms without regard to the specific questions that will appear on your exam. Please do not use these questions as an indication of which specific topics will appear on this term's midterm.

Please use these questions to help you prepare for the midterm this term. We will not be providing solutions for these questions, as we want you to use the questions to prepare under the exam-like situation of not knowing the answer, and you working through ways to check your work on your own, rather than looking at the answer to check your work. If you have questions regarding the solution of these problems, please check with your instructor and/or the TAs.

Please note that Weekly Joys has a good number of sample exam questions from past terms for which solutions are provided.

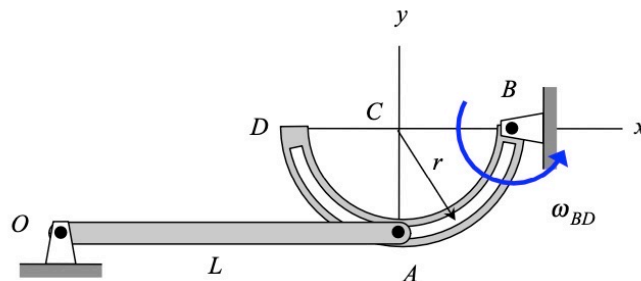
ME 274 – Summer 2014
Examination No. 1
PROBLEM NO. 2 – 20 points

Given: A mechanism is made up of links OA and BD. End A of link OA is constrained to move within a circular slot in link BD, with the slot having a radius of r and the center of the circular slot at point C. Link BD is rotating in the counterclockwise sense with a constant angular speed of ω_{BD} . At the instant shown, C is directly to the left of pin joint B and link OA is horizontal.

Find: Determine the angular velocity and angular acceleration of link OA for the position shown. Write your answers as vectors. If you use a moving reference frame in your analysis, clearly indicate to what body your observer is attached.

Use the following parameters in your final answer: $r = 0.5 \text{ ft}$, $L = 2 \text{ ft}$ and

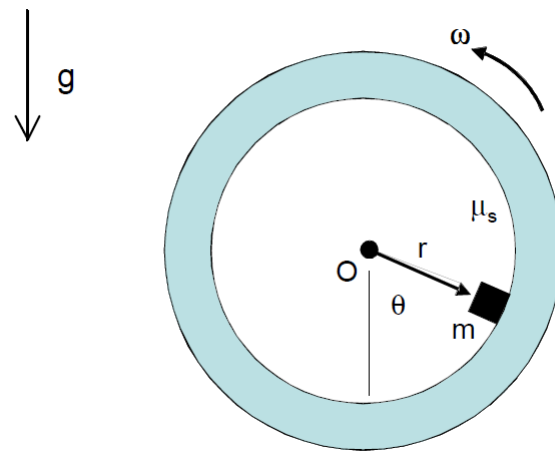
$$\omega_{BD} = 5 \text{ rad / sec}.$$



Problem 1 (20 points):

Given: The drum of an industrial polisher, shown below, rotates about point O with a constant speed ω . A small cube of aluminum is placed on the inner surface of the drum. It is observed that this piece of metal has no motion relative to the polisher's surface as it passes through $\theta = 0$.

Find: Find a relationship between r , μ_s , g , ω , and the critical angular orientation of the drum θ_{crit} at which the block first slips.



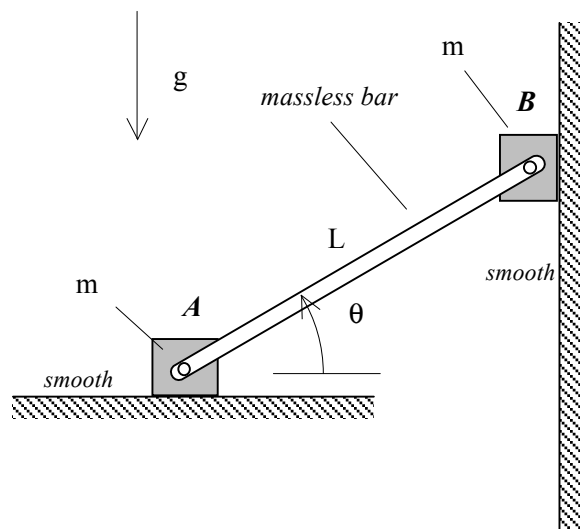
ME 274 – Summer 2011
Examination No. 2 - makeup
PROBLEM NO. 1

Name _____

Given: System released from rest with $\theta = 36.87^\circ$. Consider bar AB to have negligible mass.

Find: Determine the *angular velocity* of the bar when $\theta = 0$. Use: $m = 100 \text{ kg}$ and $L = 2 \text{ meters}$.

Please clearly indicate the four steps in a neat and orderly presentation of your work.



Examination No. 2

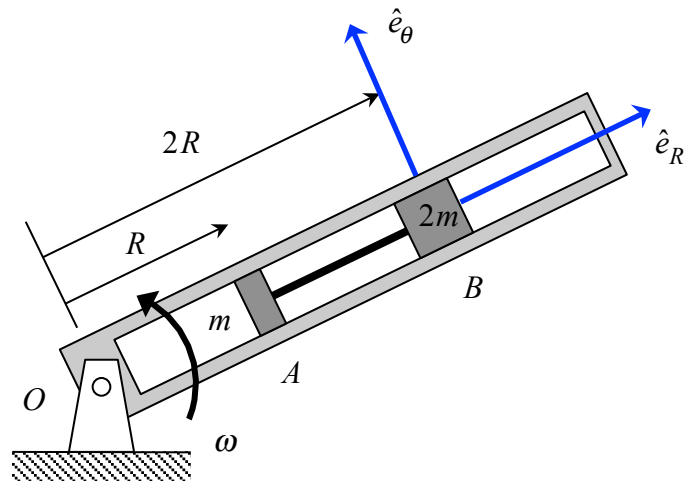
PROBLEM NO. 1 – 20 points

Given: Particles A and B (having masses of m and $2m$, respectively) slide inside a tube. The particles are connected by an inextensible cable of length R . The tube rotates about the fixed point O with the tube remaining in the same horizontal plane (i.e., gravitational forces do NOT affect the motion of A and B). At the instant shown, the tube is rotating with a *constant* angular speed ω , with particles A and B at distances R and $2R$ from O and with these particles moving outward within the tube at a rate of \dot{R} . (Please note that $\dot{R} \neq 0$.) All surfaces are to be considered smooth.

Find: For this problem:

- Draw individual free body diagrams for particles A and B.
- Determine the tension in the cable AB.
- Determine the normal force acting on particle B due to the tube as the system rotates.

HINT: Use the polar coordinate system shown in your analysis.



HORIZONTAL PLANE

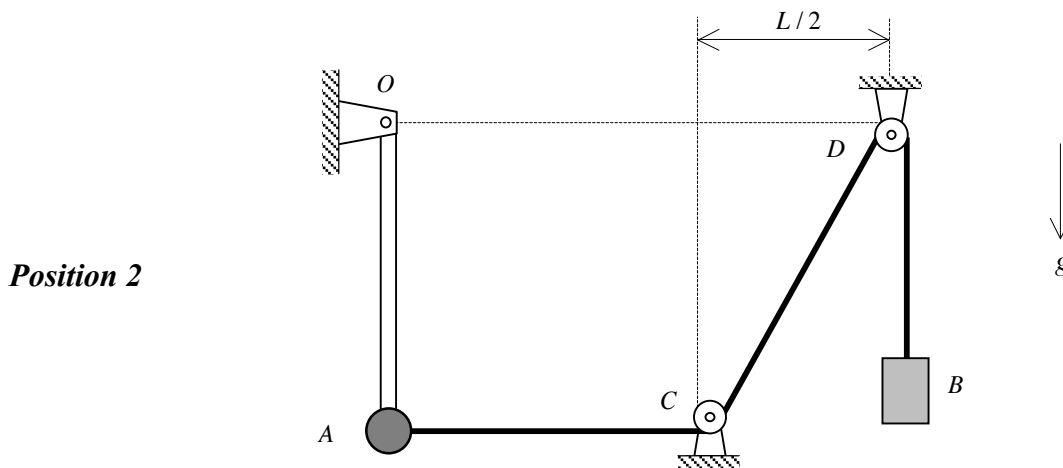
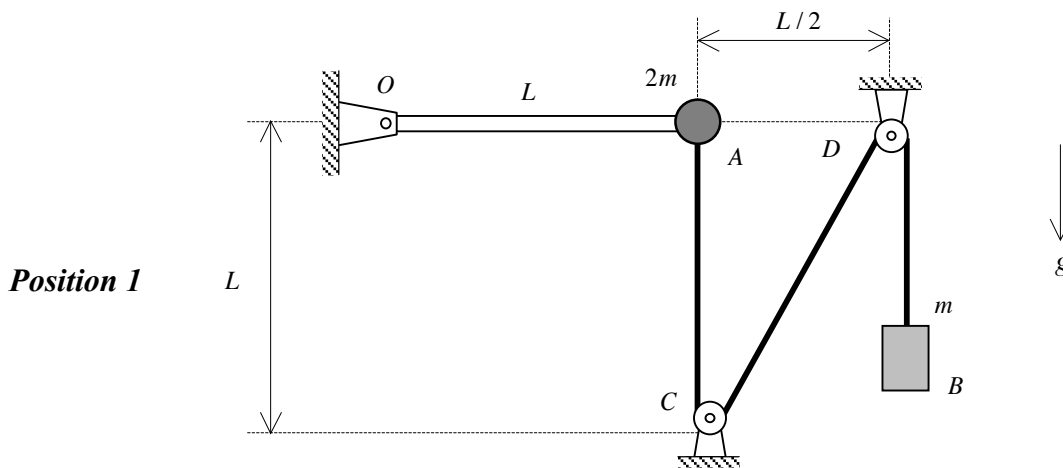
Examination No. 2

PROBLEM NO. 3

Given: Particle A (of mass $2m$) is attached to a rigid bar of negligible mass. Particle A is also connected to a cable that is wrapped around two pulleys and connected to particle B on its other end. The system is released from rest with OA being horizontal and with section AC of the cable being vertical. Assume that the radii of the pulleys to negligible.

Find: Determine the *angular velocity* of the bar at Position 2 where it has rotated 90° CW to a vertical orientation. (At Position 2, section AC of the cable is horizontal.) Use the following parameter values in your work: $m = 10\text{kg}$ and $L = 4\text{ meters}$.

Please clearly indicate the four steps in a neat and orderly presentation of your work.



PLEASE START YOUR ANALYSIS ON THE NEXT PAGE.

Examination No. 2

PROBLEM NO. 2

Given: Particle A (of mass m) slides upon a *smooth* HORIZONTAL surface. A flexible, inextensible cord is connected to A at one end and has a constant force \vec{F} acting to the left on the other end. Initially, when A is at a radial distance of $R = R_1$ from O, the cord is in contact with a small, smooth peg at O. At this instant, A is moving perpendicular of line OA with a speed of v_{A1} , as shown in the figure.

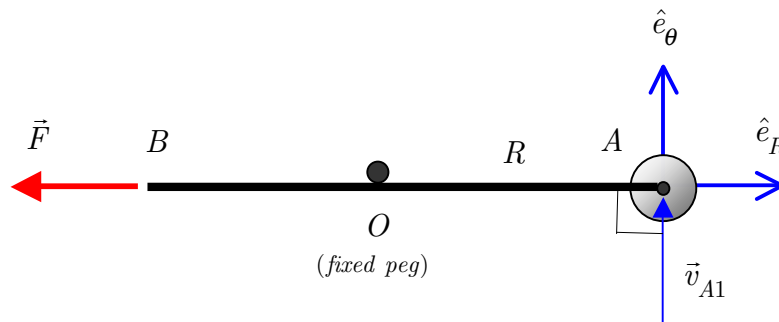
Find: When A is at a radial distance of $R = R_2$ from O, determine the speeds of ends A and B of the cord. Use the following parameter values in your work:

$$m = 10\text{kg}, R_1 = 2 \text{ meters}, R_2 = 3 \text{ meters}, |\vec{F}| = 280 \text{ N and}$$

$$v_{A1} = 15 \text{ m / sec.}$$

HINT: Draw an FBD of particle A and the cord together as your system. Use both the work/energy equation and the angular impulse/momentum equation for the system in your work. If you use conservation of either energy or angular momentum, justify!

Please clearly indicate the four steps in a neat and orderly presentation of your work.



HORIZONTAL SURFACE

ME 274 – Summer 2012
Examination No. 2
PROBLEM NO. 3

Name _____

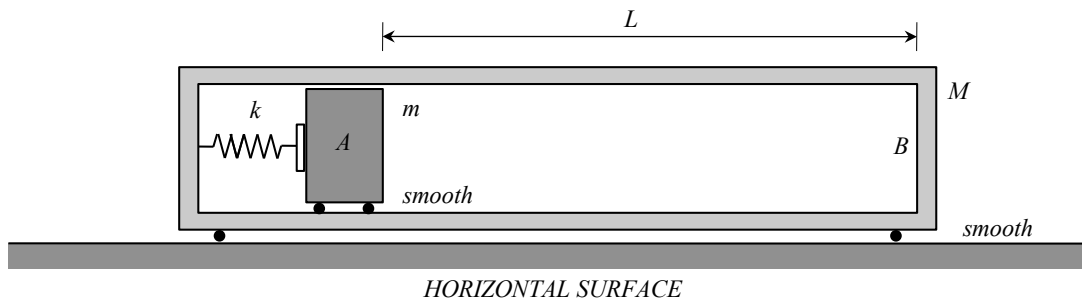
Given: A box having a mass of M is constrained to move along a smooth, horizontal surface. Block A (having a mass of m) is able to slide along smooth, horizontal surface inside the box, as shown in the figure below. Block A is pressed against a spring having a stiffness of k . Initially, the system is at rest and the spring is compressed by an amount Δ_1 . The coefficient of restitution between A and the box at end B is e .

Find: After the spring is released:

- Determine the speed of the box and the speed of block A immediately BEFORE A impacts the box at B. Write your answers as vectors.
- Determine the speed of the box and the speed of block A immediately AFTER A impacts the box at B. Write your answers as vectors.

Use the following: $m = 3\text{ kg}$, $M = 5\text{ kg}$, $k = 12,000\text{ N/m}$, $e = 0.5$, $\Delta_1 = 0.3\text{ m}$ and $L = 2\text{ m}$.

Please clearly indicate the four steps in a neat and orderly presentation of your work.

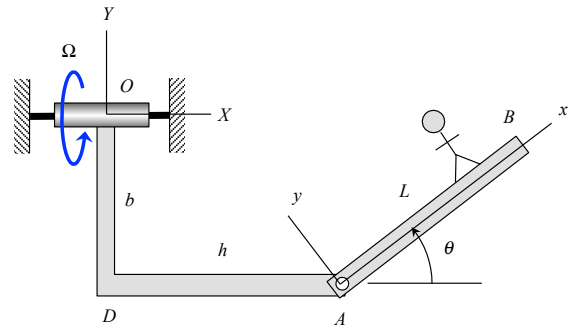


Work appearing above this line will NOT be graded.

NOTE: You are NOT asked to provide justification for your answers here in Problem 1. A correct response will receive full credit. Any work provided will not be graded, only the final answer.

PROBLEM NO. 1 - PART A

The L-shaped member ODA rotates about a fixed axis at end O at a constant rate of Ω . Arm AB is pinned to ODA at A. The angle θ between line DA and AB is being increased at a constant rate of $\dot{\theta}$. An observer is placed on arm AB, along with the xyz -axes being attached to AB. It is desired to use the following moving reference frame equation to determine the acceleration of point B:



$$\vec{a}_B = \vec{a}_A + \left(\vec{a}_{B/A}\right)_{rel} + \vec{\alpha} \times \hat{r}_{B/A} + 2\vec{\omega} \times \left(\vec{v}_{B/A}\right)_{rel} + \vec{\omega} \times \left(\vec{\omega} \times \vec{r}_{B/A}\right)$$

Provide expressions for the following terms in the above equation. Write your answers in terms of their xyz -components and leave the answers in terms of, at most: Ω , θ , $\dot{\theta}$, b , h and L .

2 points – $\vec{\omega} =$

2 points – $\vec{\alpha} =$

2 points – $\left(\vec{v}_{B/A}\right)_{rel} =$

2 points – $\left(\vec{a}_{B/A}\right)_{rel} =$

2 points – $\vec{a}_A =$

Examination No. 2

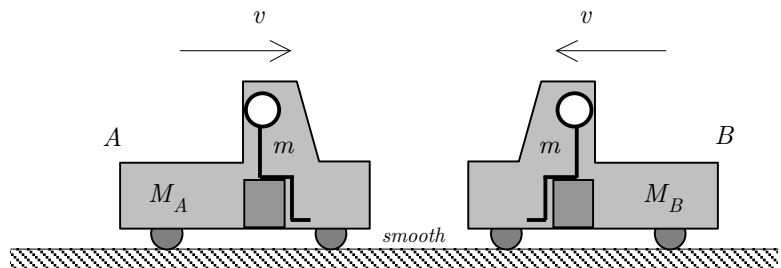
PROBLEM NO. 4c (4 points max)

Given: Trucks A and B (having masses of M_A and M_B , respectively, where $M_A = 2M_B$) experience a low-speed, head-on collision on an icy road. The drivers of these two trucks (each having the same mass m) are both securely constrained by shoulder harnesses (and, fortunately, are not injured in the collision). Let F_A and F_B represent the magnitudes of the respective forces acting on the drivers by their shoulder harnesses during the collision. Assume that the collision does not do appreciable damage to either truck and that the trucks behave as rigid bodies during impact.

Find: Circle the answer below that most accurately describes the size of the force F_A as compared to the force F_B :

- a) $F_A < F_B$
- b) $F_A = F_B$
- c) $F_A > F_B$
- d) More information is needed about the collision to answer this question.

Provide a mathematical justification for your answer.

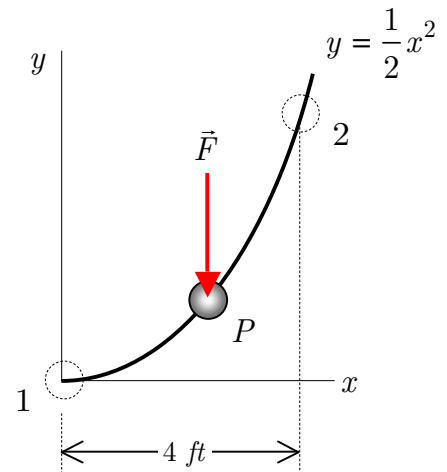


Examination No. 2

PROBLEM NO. 4a (4 points max)

Given: Particle P moves along a curved guide whose shape is given by the Cartesian description of $y = \frac{1}{2}x^2$, where x and y are given in feet. Between positions 1 and 2 shown on the figure below, a downward force \vec{F} having a *constant* magnitude of 100 lbs acts on P.

Find: Determine the work done on P by \vec{F} in going from position 1 to position 2.



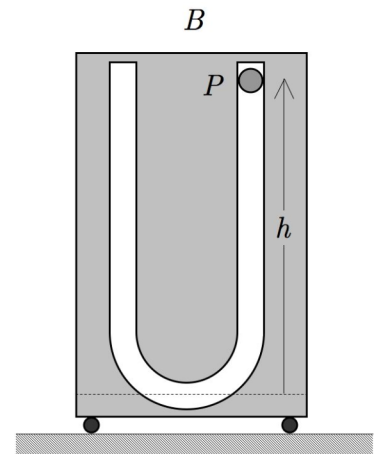
Examination No. 2

PROBLEM NO. 4b (4 points max)

Given: Particle P (of mass m) is allowed to slide within a smooth slot cut into block B (of mass $2m$). Block B is allowed to slide along a smooth horizontal surface. At instant “1”, the system of P and B is at rest. At instant “2”, particle P has slid to the bottom of the slot.

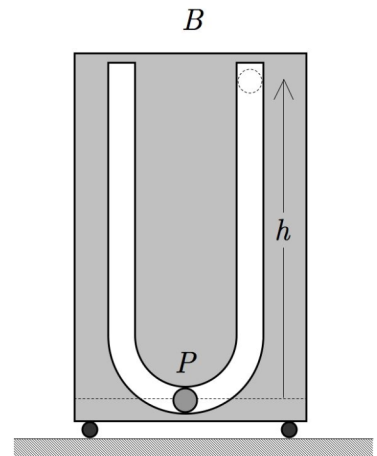
Find: Circle the response below that most accurately describes the speed of block B at instant “2”:

- a) $v_{B2} = 0$
- b) $v_{B2} = \sqrt{gh / 3}$
- c) $v_{B2} = \sqrt{gh / 2}$
- d) $v_{B2} = \sqrt{gh}$
- e) $v_{B2} = \sqrt{2gh}$
- f) $v_{B2} = \sqrt{3gh}$
- g) none of the above



instant "1"

Provide a mathematical justification for your response.



instant "2"

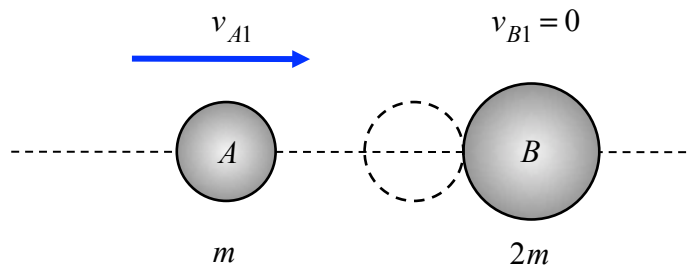
ME 274 – Summer 2015 Name _____
Examination No. 2
PROBLEM NO. 3 (continued)

PART B – 3 points

Particle A, of mass m , is moving to the right with a speed of v_{A1} when it strikes a stationary particle B (having a mass of $2m$). For a coefficient of restitution between A and B of $e = 0.2$, circle the answer below that most accurately describes the motion of A after impact:

- a) A is moving to the right.
- b) A is stationary.
- c) A is moving to the left.
- d) A numerical value for v_{A1} is needed to answer this question.

You do NOT need to provide justification for your answer.

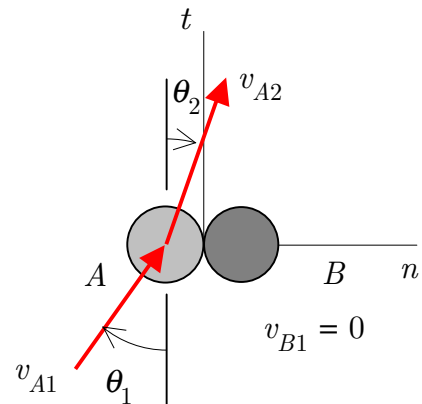


Examination No. 2

PROBLEM NO. 4c (5 points max)

Given: Particle A (of mass m) is traveling with a speed of v_{A1} in the direction shown below when it strikes a stationary particle B (of mass m). The coefficient of restitution for the impact of A with B is known to be $e = 0$.

Find: If $\theta_1 = 36.87^\circ$, what is the direction of travel of particle A *after* impacting B? Provide a mathematical justification for your answer.



Examination No. 2

PROBLEM NO. 4b (5 points max)

Given: Particle P (of mass m) is dropped from rest at a height of h above a stationary, ground surface. The duration of the impact of P with the ground is known to be Δt , and the coefficient of restitution of the impact is e .

Find: Determine the average impact force on P. Use the following parameters in your analysis: $m = 2 \text{ kg}$, $h = 0.5 \text{ meters}$, $e = 0.5$ and $\Delta t = 0.01 \text{ seconds}$.

