More sample exam problems - ME 274 – Final Exam

The following is a set of ME 274 Final Exam problems from past school terms. Please feel free to use these problems in your preparation for your exam this semester. Please do not use these problems to suggest which topics that will or will not be covered on your exam, nor to suggest the level of difficulty that you should expect on your exam.

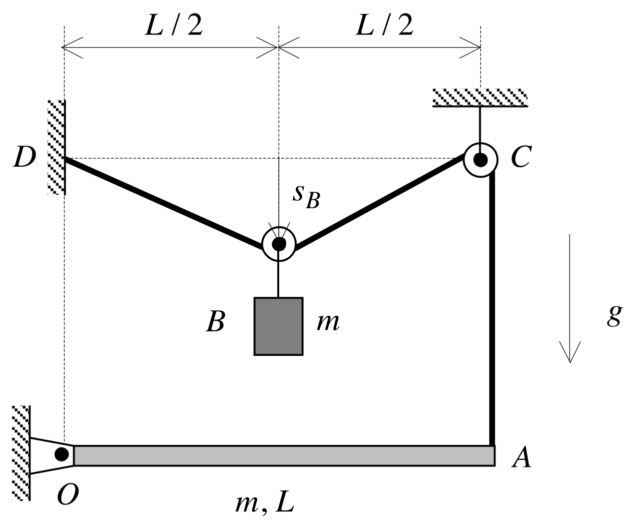
These problems are provided to you for a set of talking points in your interaction with instructors, TAs and colleagues. In particular, these questions will likely be covered during the course-wide exam review session. We will NOT be providing solutions for these problems otherwise.

ME 274 – Summer 2011 **Name ________________________________**
Final Exam
PROBLEM NO. 1

***Given*:** A homogeneous bar OA (of mass m and length L) is pinned to ground at end O. End A of the bar is connected to an inextensible cable that is pulled over pulley C and attached to ground at D. Block B (of mass m) is connected to a pulley that is supported by the cable midway between C and D. The system is released from rest with OA being horizontal, section AC of the cable vertical and with B at a distance s_B below line CD. Consider the pulleys to be small and massless. On release, block B moves only in the vertical direction.

***Find*:** Determine acceleration of block B on release. Use: $m = 100\ kg$, $L = 8\ meters$ and $s_B = 3m$.

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



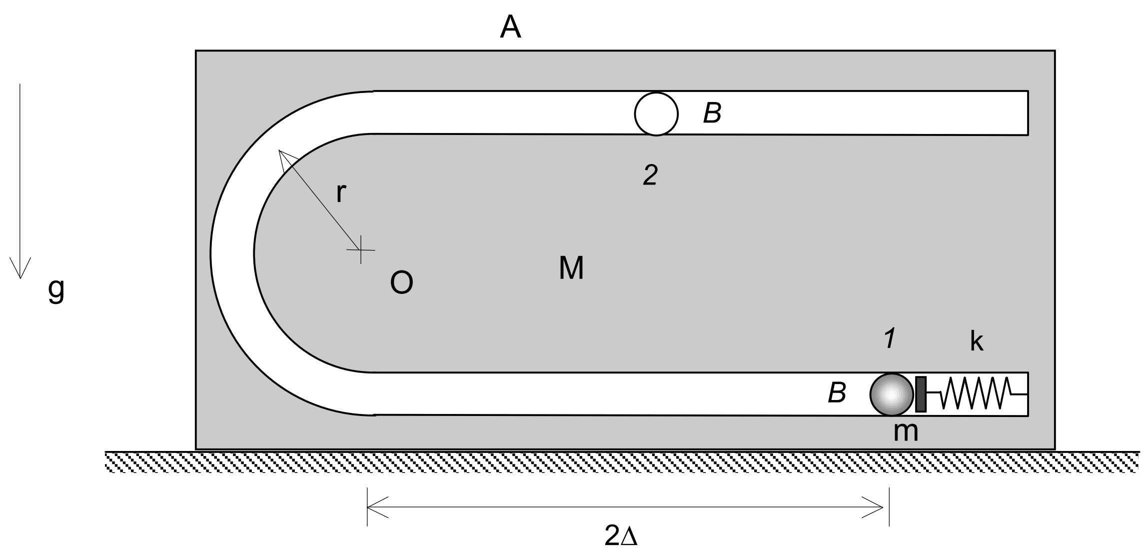
ME 274 – Summer 2009 **Name** ______________________________
Final Examination
PROBLEM NO. 3

Given: Particle B, having a mass of m, is pressed against a spring (of stiffness k) that is attached to cart A. Cart A (having a mass of M) rests on a horizontal surface. The system is *released from rest* when B is at Position 1 with the spring compressed by an amount of Δ. After release, B travels within a slot cut into cart A, with the slot having straight horizontal and circular sections (the circular section has a radius of r and center at O). A position 2, B has reached the upper horizontal slot but has not yet impacted the cart at the right end of this slot.

Find: Determine the velocities of A and B when B is at Position 2. Write your answers as vectors.

Note that since B is simply pressed against the spring, the spring *can push but not pull* on B. Assume all surfaces to be smooth.

Use the following parameters in your analysis: $m = 30 kg$, $M = 60 kg$, $k = 3000\ N/m$, $\Delta = 0.5\ meters$ and $r = 0.2\ meters$.



PLEASE START YOUR WORK ON THE NEXT PAGE.

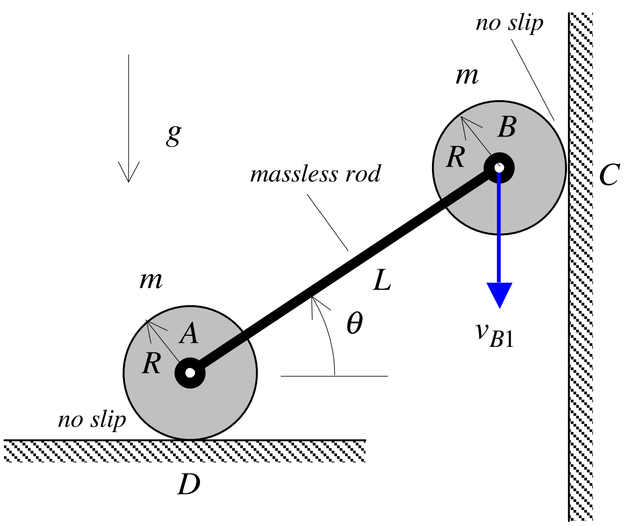
ME 274 – Summer 2010 **Name ______________________________**
Final Exam
PROBLEM NO. 1

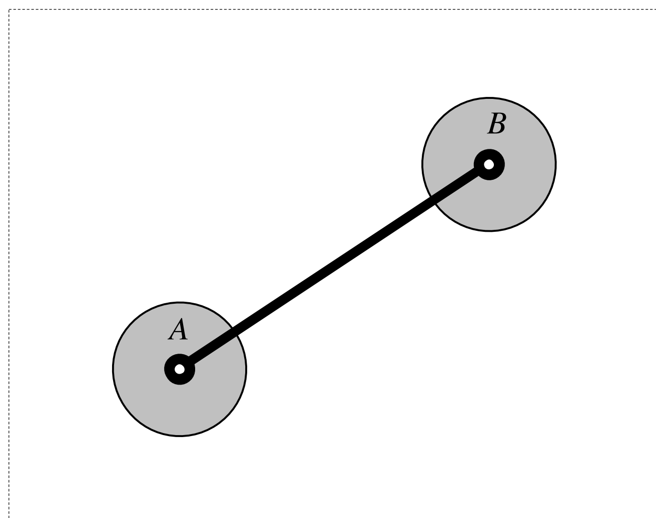
Given: System released at $\theta = 53.13°$ with the center of the disk moving downward with a speed of v_{B1}. Consider the bar and the disk to be homogeneous.

Find: Determine the *angular velocity* of disk B when $\theta = 0$. Use: $m = 100\ kg$, $L = 3\ meters$, $v_{B1} = 4\ m/sec$ and $R = 0.5\ meters$.

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

HINT: Consider using the work-energy equation on the system made up of the two disks and the massless rod.





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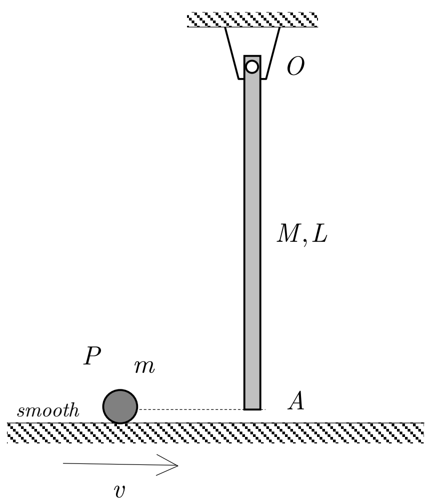
PROBLEM NO. 2

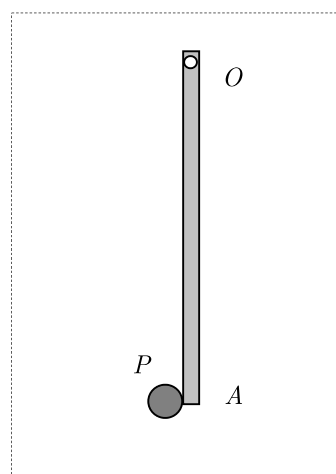
Given: Particle P (of mass m) slides along a smooth horizontal surface with a speed of v. P then strikes end A of a stationary thin, homogeneous bar (of length L and mass M) that is pinned to ground at O. The coefficient of restitution for the impact of P with end A of the bar is known to be e.

Find: Determine the angular speed of bar OA immediately after the impact. Use the following parameters in your analysis: $m = 10kg$, $M = 30\,kg$, $L = 2\ meters$, $v = 40\,m\,/\,sec$ and $e = 0.5$.

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

HINT: Consider using the angular impulse-momentum equation about point O for the system made up of the bar and the particle.





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Final Examination

PROBLEM NO. 2 – 20 points

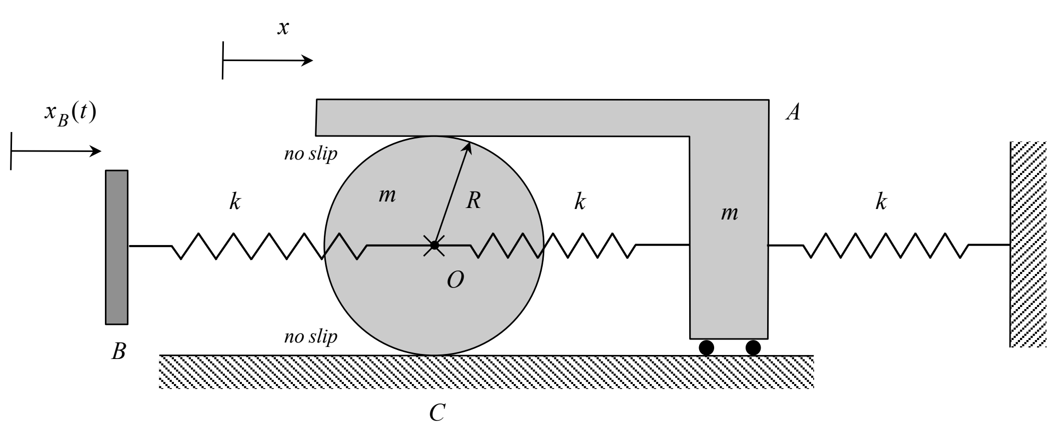
Given: A homogeneous disk (having a mass of m and outer radius R) is able to roll without slipping on a horizontal surface. A spring of stiffness k is attached between the center O of the disk and a moveable base B. A second spring (also of stiffness k) is attached between O and an L-shaped block A, with an arm of block A resting on the top surface of the disk. A third spring (also of stiffness k) is attached between A and a fixed wall on the right. As the system moves, the arm of block A does not slip on the top surface of the disk. Let x represent the motion of block A, and $x_B(t) = b \sin \omega t$ represent the motion of the base B. When $x = x_B = 0$, the springs are unstretched.

Find: For this problem:

a) Draw individual free body diagrams (FBDs) of the disk and of block A.

b) From your FBDs, derive the differential equation of motion (EOM) of the system in terms of the coordinate x.

c) Determine the particular solution of the EOM, with this solution describing the steady-state motion of block A. Leave your answer in terms of the parameters of the problem.



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Final Examination

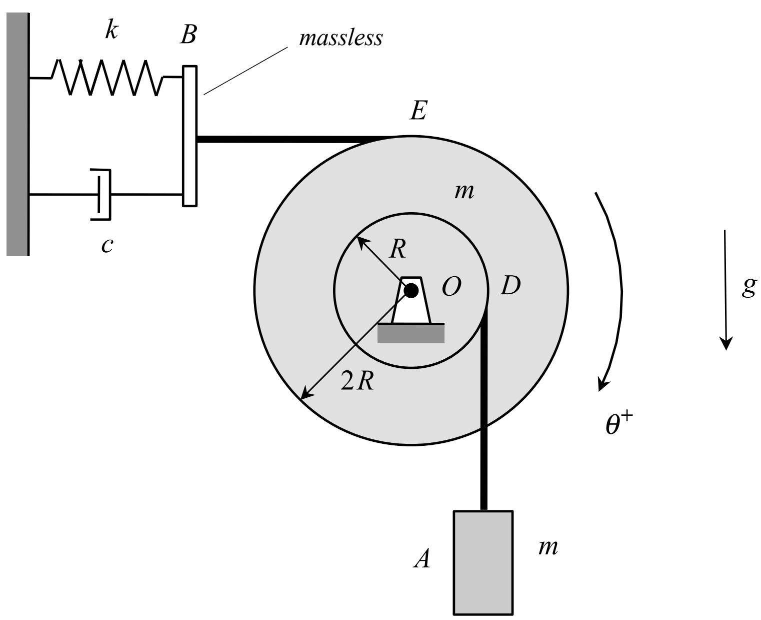
PROBLEM NO. 4

Given: A stepped pulley (of mass m and centroidal radius of gyration k_O) is pinned to ground at its center O. A cable is wrapped around the inner radius of the pulley with block A (of mass m) attached to the free end of the cable. A second cable is wrapped around the outer radius of the pulley with block B (of negligible mass) attached to the free end of this cable. Block B is attached to ground through a spring of stiffness k and a dashpot of damping constant c, as shown in the figure below. Assume that the cables do not slip on the pulley. Let θ represent the angular rotation of the pulley with the spring being unstretched when $\theta = 0$.

Find: For this problem:

a) Derive the equation of motion (EOM) for the system corresponding to the coordinate θ. Leave your EOM in terms of the parameters of: m, k_O, R, k, c and g. Clearly indicate the four steps in a neat and orderly presentation of your work.

b) Determine the undamped natural frequency ω_n and the damping ratio ζ for the system. Use the following parameters: $m = 16 kg$, $k = 500 N/m$, $R = 1 m$, $k_O = 0.5 m$ and $c = 20 kg/sec$.



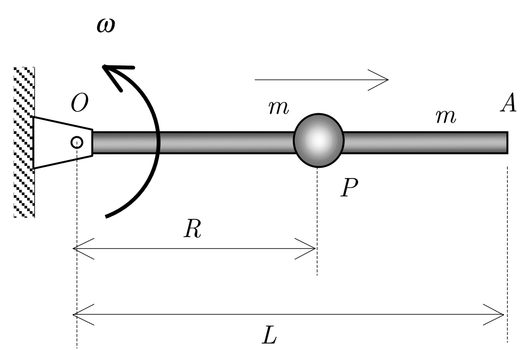
Work appearing above this line will NOT be graded.

ME 274 – Summer 2011 **Name** ______________________________
Final Exam
PROBLEM NO. 5a *(5 points max)*

Given: Thin homogeneous bar OA (of mass m and length L) is pinned to ground at end O and is rotating in the CCW sense with an angular speed of ω. Particle P (of mass m) slides *outward* on the bar ($\dot{R} > 0$) as bar OA rotates.

Find: Determine the vector expression for the *total angular momentum about point O of the system of bar OA + particle P*. Use the following parameters in your analysis: $R = 0.5\, meters$, $\omega = 6\, rad\ /\ sec$, $\dot{R} = 4\, ft\ /\ sec$, $m = 8\, kg$ and $L = 1.5\, meters$.

HINT: Recall the vector expressions for the angular momentum of rigid bodies and particles about a fixed point.



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PROBLEM NO. 5b *(5 points max)*

***Given*:** The free vibration response of a spring-mass-dashpot system has the following EOM: $m\ddot{x} + c\dot{x} + kx = 0$. For a given set of values for m, c and k, this system is known to have a damping ratio of $\zeta = 0.8$ and an undamped natural frequency of $\omega_n = 50\, rad/sec$. Now, both the *stiffness k and mass m of the system are doubled*, with c being unchanged.

***Find*:** *After this increase in stiffness and mass:*

a) determine the numerical value for the *damping ratio* ζ

b) determine the numerical value for the *undamped natural frequency* ω_n

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PROBLEM NO. 5c *(5 points max)*

Given: Particle A (of mass m) strikes a fixed horizontal surface with a speed of v. Particle B (of mass 2m) also strikes the same horizontal surface with a speed of v. Both impacts have the same coefficient of restitution e.

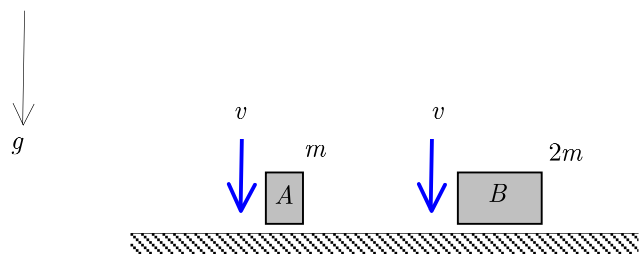
Find: Circle the response below that most accurately describes the *maximum rebound heights* of A and B after impact:

a) Particle A bounces to a *greater height* than particle B.

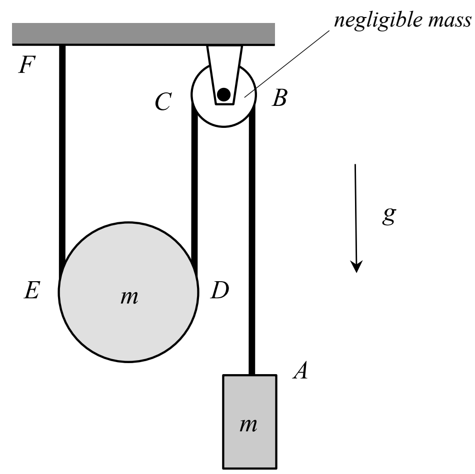
b) Particle A bounces to the *same height* as B.

c) Particle A bounces to a *lesser height* than particle B.

Provide a mathematical justification for your answer.



Part C (2 points): The circular disk and block A (each having the same mass m) are supported by the single cable shown. All sections of the cable not wrapped around the pulley and disk are vertical. The pulley has negligible mass. The system is released from rest. Let T_{AB}, T_{CD} and T_{EF} represent the tensions in sections AB, CD and EF, respectively, of the cable. Assume that the cable does not slip on the disk.



Circle the answer below that correctly describes the relative sizes of T_{AB} and T_{CD}:

a) $T_{AB} > T_{CD}$
b) $T_{AB} = T_{CD}$
c) $T_{AB} < T_{CD}$

Part D (3 points): Consider again the system in Part D above. Circle the answer below that correctly describes the relative sizes of T_{CD} and T_{EF}:

a) $T_{CD} > T_{EF}$
b) $T_{CD} = T_{EF}$
c) $T_{CD} < T_{EF}$

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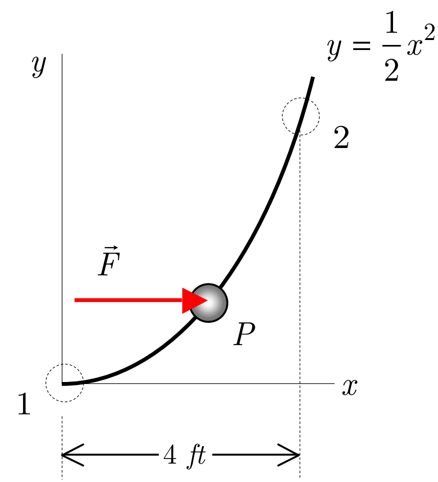
PROBLEM NO. 5a *(5 points max)*

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 force $\vec{F}$ having a *constant* magnitude of $100\ lbs$ acts on P to the right.

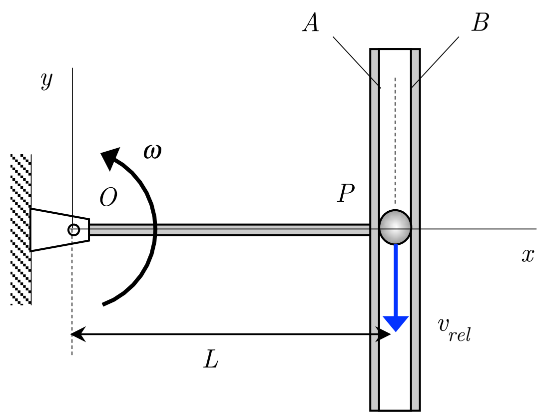
Find: Determine the work done on P by $\vec{F}$ in going from position 1 to position 2.



PART D – 5 points

Particle P of mass m slides in the direction shown within a smooth tube with a constant speed of v_{rel} relative to the tube as the tube rotates in the CCW sense with *constant* angular speed of ω.

On which side of the tube (*side A* or *side B*) is P in contact with the tube at the position shown below? Use the following parameters in your analysis:
$\omega = 3\,rad\,/\,sec = constant$, $v_{rel} = 4\,ft\,/\,sec = constant$ and $L = 2\,ft$.



HORIZONTAL PLANE