"Rapid fire" questions from Chapter 4 – Kinetics of Particles
ME 274 – Spring 2025
cmk

Attached is a set of problems from past exams in this course that are related to the material on particle kinetics found in Chapter 4. I would like for us to use these problems to sharpen our skills on two issues: 1) deciding which method(s) to use in solving the problem (Newton's 2^{nd} law, the work/energy equation, the linear impulse momentum equations and/or the angular impulse momentum equations), and 2) drawing the appropriate free body diagram(s) for solving the problems. I am calling these "rapid fire" questions in that these are two issues that you with which you need to be extremely comfortable, and that you can handle in a relatively short time at the beginning of the problem solution. Also attached here is page 352 of the course lecture book which can be helpful in guiding you on your choice of method(s) to use in solving.

With this, I challenge you to do these two steps on the following problems. You may continue on with the solution beyond these two steps of course; however, focus on developing skills in answering these two steps first before solving.

Kinetics Table

Method	Body model	Fundamental equations
Newton-Euler *(relating forces to accelerations)*	**particle**	$\sum \vec{F} = m\vec{a}$
	rigid body *(G = c.m. and A = any point on body)*	$\sum \vec{F} = m\vec{a}_G$ $\sum \vec{M}_A = I_A\vec{\alpha} + m\vec{r}_{G/A} \times \vec{a}_A$
Work-energy *(relating change in speed to change in position)*	**particle**	$T_1 + V_1 + U_{1\to 2}^{(nc)} = T_2 + V_2$ $where\ \ T = \frac{1}{2}mv^2$
	rigid body *(G = c.m. and A = any point on body)*	$T_1 + V_1 + U_{1\to 2}^{(nc)} = T_2 + V_2$ $where\ \ T = \frac{1}{2}mv_A^2 + \frac{1}{2}I_A\omega^2 + m\vec{v}_A \bullet \left(\vec{\omega} \times \vec{r}_{G/A}\right)$
Linear impulse-momentum *(relating change in velocity to change in time)*	**particle**	$\int_{t_1}^{t_2} \sum \vec{F}\, dt = m\vec{v}_2 - m\vec{v}_1$
	rigid body *(G = c.m.)*	$\int_{t_1}^{t_2} \sum \vec{F}\, dt = m\vec{v}_{G2} - m\vec{v}_{G1}$
Angular impulse-momentum *(relating change in angular velocity to change in time)*	**particle** *(O = fixed point)*	$\int_{t_1}^{t_2} \sum \vec{M}_O\, dt = \vec{H}_{O2} - \vec{H}_{O1}$ $where\ \ \vec{H}_O = m\vec{r}_{P/O} \times \vec{v}_P$
	rigid body *(A = fixed point or c.m.)*	$\int_{t_1}^{t_2} \sum \vec{M}_A\, dt = \vec{H}_{A2} - \vec{H}_{A1}$ $where\ \ \vec{H}_A = I_A\vec{\omega}$

ME 274 – Summer 2009 **Name ________________________________**
Examination No. 2
PROBLEM NO. 1

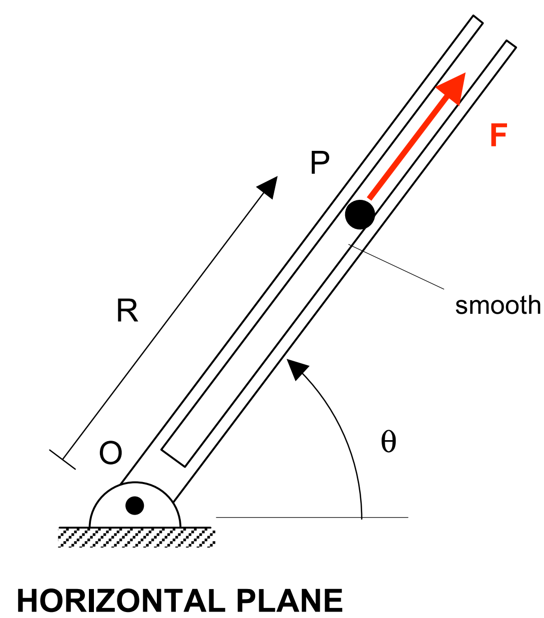
Given: Pellet P having a mass of m is pulled through a barrel (having negligible mass) by means of radial force $F = 60R$, where F is in Newtons and R is in meters. The barrel is constrained to move in a HORIZONTAL plane by rotating about shaft passing through point O. The system is released with $R = R_1$, $\dot{R} = \dot{R}_1$ and $\dot{\theta} = \dot{\theta}_1$.

Find: For the instant when $R = R_2$:

a) determine the rotation rate of the barrel, $\dot{\theta}_2$.

b) determine the value of $\dot{R}_2$.

Use the following parameters in your analysis: $m = 20\,kg$, $R_1 = 1.5\ meters$, $\dot{R}_1 = 4\ m/sec$, $\dot{\theta}_1 = 8\ rad/sec(CCW)$ and $R_2 = 3\ meters$.



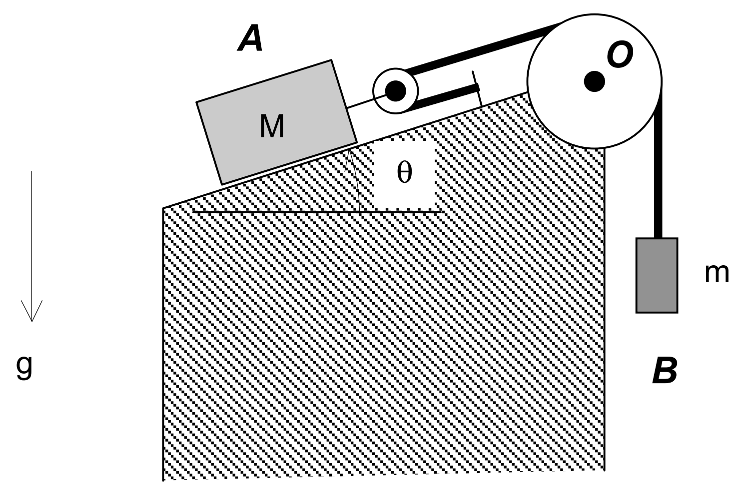
ME 274 – Summer 2009 ***Name ______________________________***
Examination No. 2
PROBLEM NO. 3

Given: Blocks A and B are connected by the cable-pulley shown. The system is released from rest. Consider all surfaces to be smooth and that the masses of the pulleys are small compared to the masses of A and B.

Find: Upon release,

a) determine the acceleration of block B. Write your answer as a vector.
b) determine the tension in the cable.

Use the following parameters in your analysis: $m = 5kg$, $M = 20kg$ and $\theta = 36.87°$.



ME 274 – Summer 2009   ***Name ______________________________***
Examination No. 2
PROBLEM NO. 4

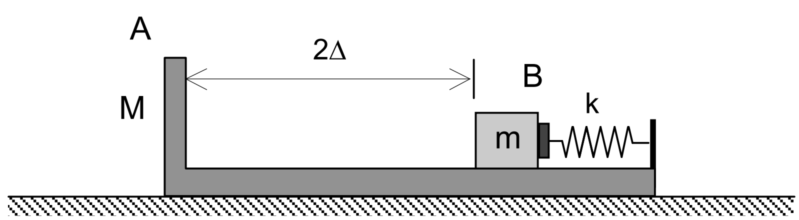
***Given*:** Block B, having a mass of m, is pressed against a spring (of stiffness k) that is attached to cart A. Cart A (having a mass of M) rests on a horizontal surface. The system is released from rest with the spring compressed by an amount of Δ. After release, block B impacts A, with this impact having a coefficient of restitution of *e*. Assume all surfaces to be smooth. (Note that since B is simply pressed against the spring, the spring *can push but not pull* on B.)

***Find*:** For this problem,

a) determine the velocities of A and B immediately BEFORE impact.
b) determine the velocities of A and B immediately AFTER impact

Write your answers as vectors.

Use the following parameters in your analysis: $m = 20kg$, $M = 40kg$, $k = 3000\ N/m$, $\Delta = 0.2\,meters$ and $e = 0.5$.

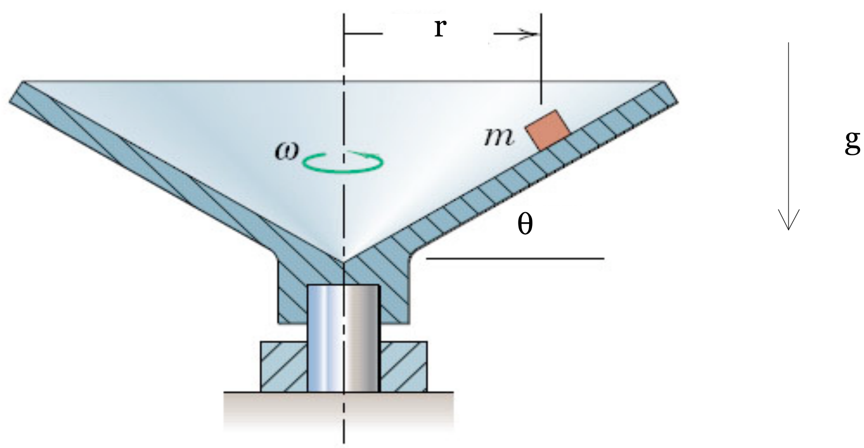


ME 274 – Summer 2009 **Name** ______________________________
Final Examination
PROBLEM NO. 1

Given: A small object of mass m is placed on the inner surface of a conical dish that is rotating at a constant rate of ω. The coefficients of static and kinetic friction between the object and the dish are known to be μ_s and μ_k, respectively.

Find: Determine the *maximum* rotation rate ω for which the object does not slip on the dish.

Use the following parameters in your analysis: $m = 5kg$, $r = 0.92\ meters$, $\mu_s = 0.4$, $\mu_k = 0.1$ and $\theta = 36.87°$.



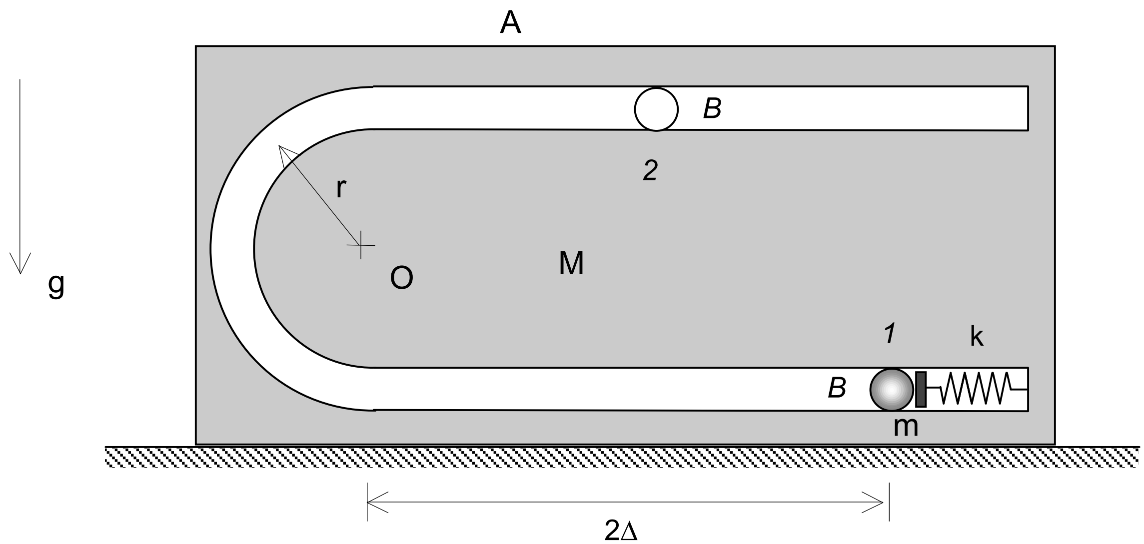
ME 274 – Summer 2009 **Name ____________________________**
Final Examination
PROBLEM NO. 3

***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: $m = 30kg$, $M = 60kg$, $k = 3000\ N/m$, $\Delta = 0.5\,meters$ and $r = 0.2\ meters$.



PLEASE START YOUR WORK ON THE NEXT PAGE.

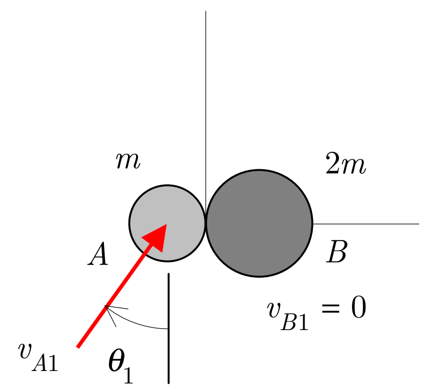
ME 274 – Summer 2010 **Name** ________________________________

Examination No. 2

PROBLEM NO. 4d *(4 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 2m). The coefficient of restitution for the impact of A with B is known to be $e = 0.5$.

Find: If $\theta_1 = 25°$, what is the direction of travel of particle A *AFTER* impacting B? Provide a mathematical justification for your answer.

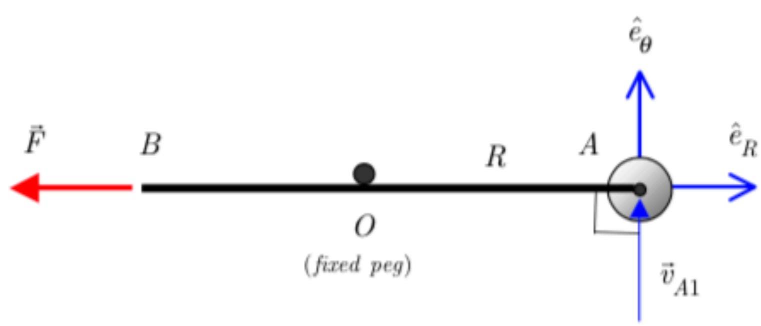


ME 274 – Summer 2011 **Name**________________________________
Examination No. 2
PROBLEM NO. 2

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: $m = 10kg$, $R_1 = 2\ meters$, $R_2 = 3\ meters$, $\left|\vec{F}\right| = 280\ N$ and $v_{A1} = 15\,m\,/\,sec$.

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



HORIZONTAL SURFACE

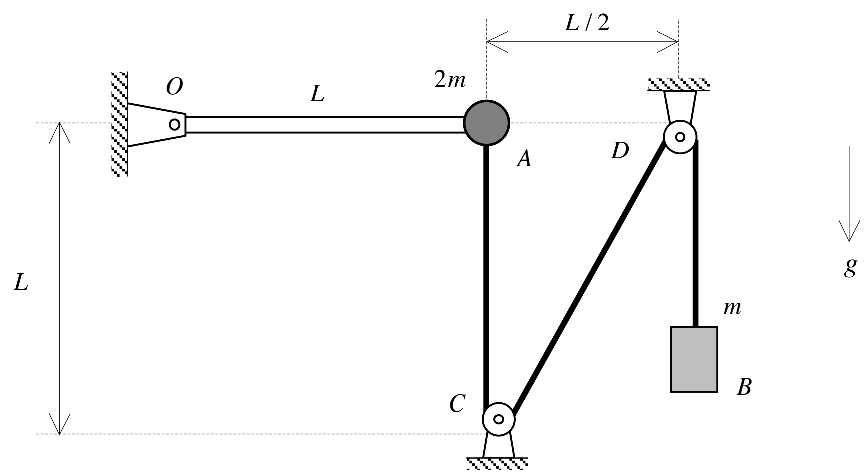
ME 274 – Summer 2011 **Name** ______________________________
Examination No. 2
PROBLEM NO. 3

***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.

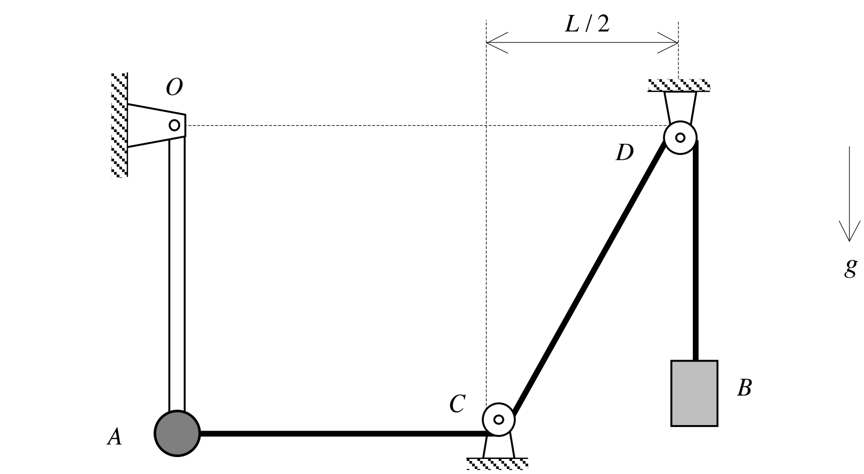
***Find*:** Determine the *angular velocity* of the bar at Position 2 where it has rotated 90° CW to a vertical orientation. (At Position 2, section AC of the cable is horizontal.) Use the following parameter values in your work: $m = 10kg$ and $L = 4\,meters$.

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

Position 1



Position 2



PLEASE START YOUR ANALYSIS ON THE NEXT PAGE.

ME 274 – Summer 2012 **Name** ______________________________

Examination No. 2

PROBLEM NO. 3

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.

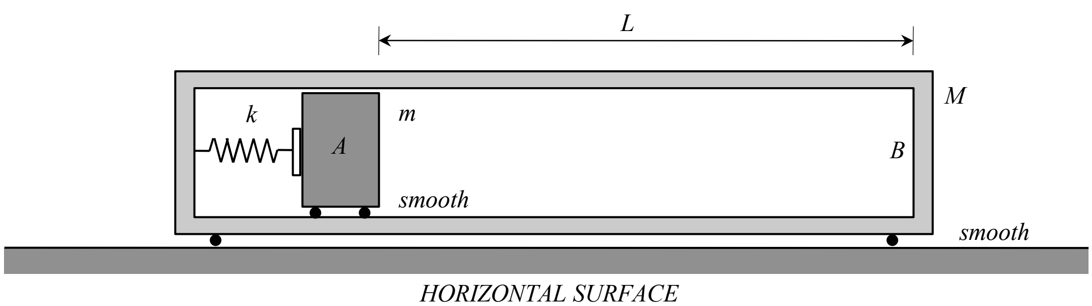
Find: After the spring is released:

a) 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.

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

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



Work appearing above this line will NOT be graded.

ME 274 – Summer 2015 **Name**__________________________________

Examination No. 2

PROBLEM NO. 2 – 20 points

***Given*:** Blocks A and B (having masses of m and 2m, respectively) are connected by rigid bar AB, with bar AB having negligible mass. Block A is constrained to move along a smooth, vertical wall, whereas block B moves along a smooth horizontal surface. The system is released from rest with $\theta = 53.13°$.

***Find*:** Determine the speeds of blocks A and B at the position where $\theta = 0$.

Use the following parameter values: $L = 2\ m$ and $m = 10\ kg$.