Physics 170 Midterm 1 Review Package

UBC Engineering Undergraduate Society

Attempt questions to the best of your ability. If you're short on time, or looking for a challenge, see the tables further down this page for specific questions that you should attempt first. There is a formula sheet attached on the last page. This review package consists of 23 pages, including 1 cover page and 15 questions. The questions are meant to be the level of a real examination or slightly above, in order to prepare you for the real exam. Material from lectures and from the relevant textbook sections is examinable, and the problems for this package were chosen with that in mind, as well as considerations based on past examination question difficulty and style. Problems are ranked in difficulty as $(*)$ for easy, $(**)$ for medium, and $(***)$ for difficult. Note that sometimes difficulty can be subjective, so do not be discouraged if you are stuck on a $(*)$ problem.

Solutions posted at: `http://ubcengineers.ca/services/academic/tutoring/` If you believe that there is an error in these solutions, or have any questions, comments, or suggestions regarding EUS Tutoring sessions, please e-mail us at: tutoring@ubcengineers.ca. If you are interested in helping with EUS tutoring sessions in the future or other academic events run by the EUS, please e-mail eus.ubc.academic@gmail.com.

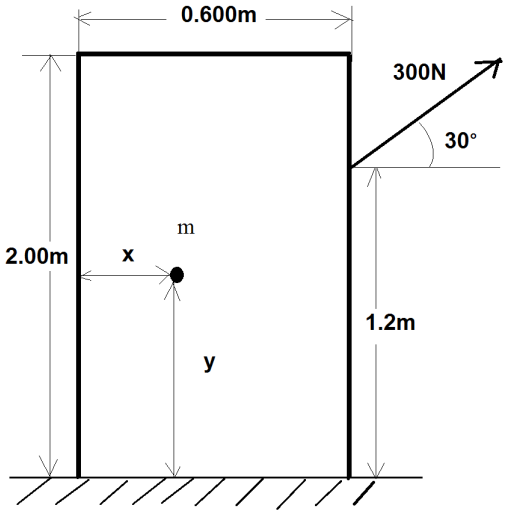
Some of the problems in this package were not created by the EUS. Those problems originated from one of the following sources:

- Fundamentals of Physics / David Halliday, Robert Resnick, Jearl Walker. – 9th ed.
- Exercises for the Feynman Lectures on Physics / Matthew Sands, Richard Feynman, Robert Leighton.

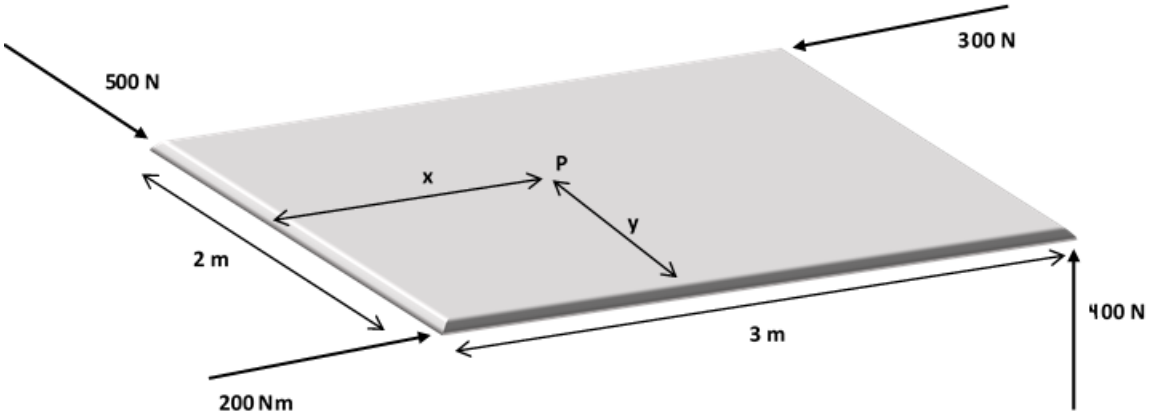
All solutions prepared by the EUS.

Good Luck!

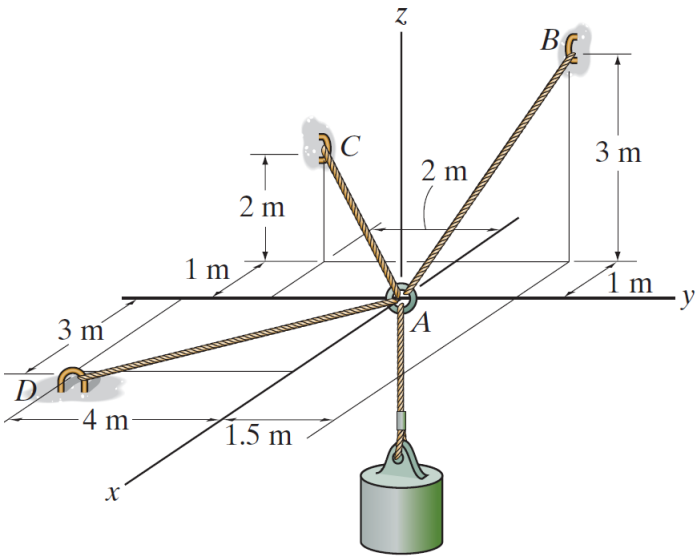
1. A 2.00m tall refrigerator of mass m has a static coefficient of friction $\mu s = 0.100$. When a pulling force of 300 N is applied as shown, the refrigerator barely slips and barely tips.
   (a) Find m and x.
   (b) With this information only, is it possible to find y? Why or why not?



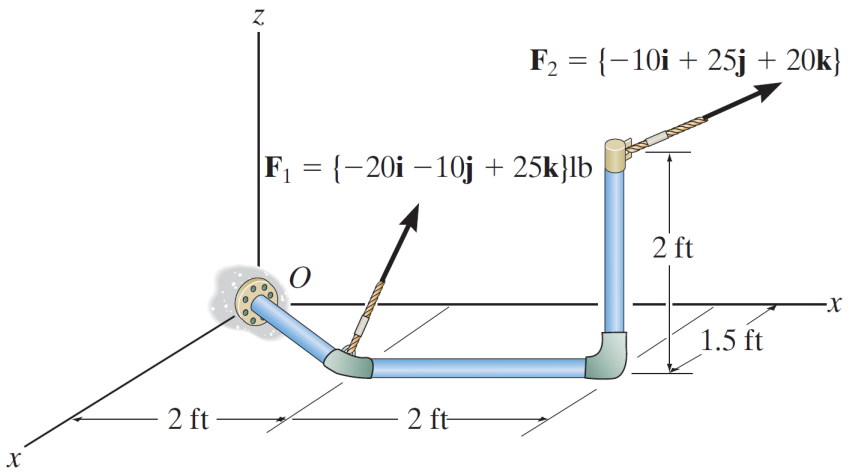
2. The diagram below shows a set of 3 forces and one moment acting on a rigid body.
   (a) Find the equivalent force and couple moment acting at point O.
   (b) Reduce all forces and moments to a single wrench acting on point P. Find the resulting force and moment vectors as well as the distances x and y.



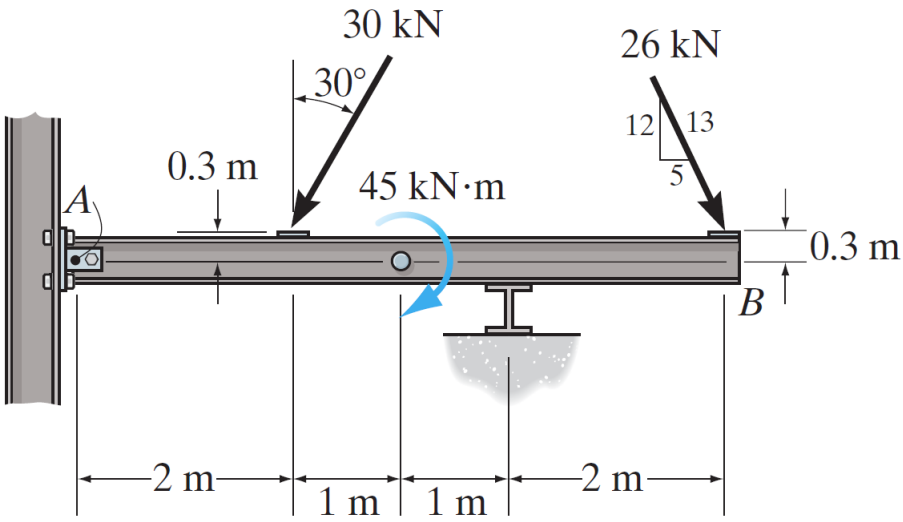
3. The Diagram below shows a mass supported by three cables which are anchored to fixed supports.
   (a) Determine the tension in each of the three cables if the cylinder has a mass of 75 kg.
   (b) If each cable can withstand a maximum tension of 1000 N, determine the largest mass that this system can support.


z
B
C
2 m
3 m
2 m
1 m
1 m
y
3 m
A
D
4 m
1.5 m
x

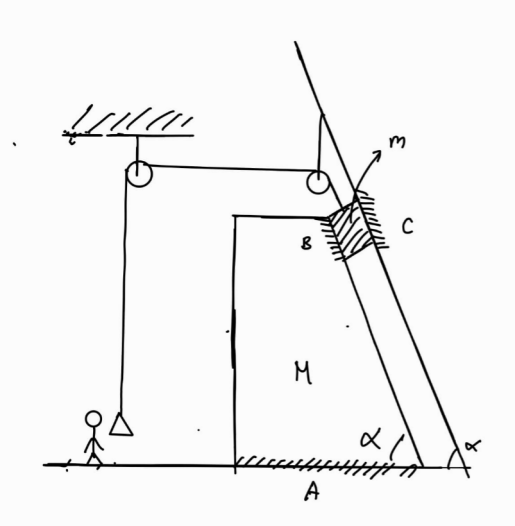
4. Replace the two forces in the diagram below with a single force and couple moment acting at point O.



5. Consider the system below of a cantilevered beam with two forces and one couple moment acting on it.
   (a) Determine the equivalent force and moment acting at point A and the I beam.
   (b) Can the forces and couple moment acting on this beam be reduced to a single force? If so, determine this force and its location along the beam.
   (c) What conditions need to be met in order to reduce a system of forces and moments to a single force? (Hint: consider the wrench problem where the system can at most be reduced to a force and couple moment)



6. (**) **Stuck in a Gap**
A UBC Student had her bag stuck on a shelf while cleaning up her basement. To make things easier, they try to pull it out of the gap as shown in the picture below.



The bag has a mass m, and we model the shelf as a wedge with mass M. It is also known that the coefficients of static friction are $\mu_A = 0.2$, $\mu_B = 0.3$, and $\mu_C = 0.4$ for the wedge and floor, bag and wedge, and also between the bag and ceiling respectively.

(It is also given that $M = 10$ kg, $m = 1.5$ kg, and $\alpha = 60°$)

(a) Draw a large, clear, free body diagram!

(b) Write down Cartesian equations for static equilibrium!

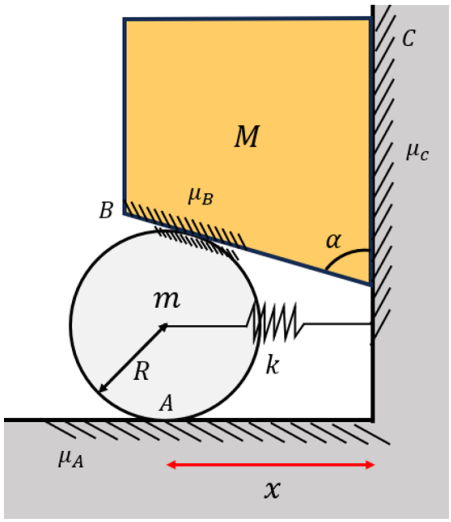
(c) List the unknown variables and determine the equations of impending motion!

(d) Find how much force must the student exert to pull out the bag.
(For extra challenge, try to solve the equations by hand)

7. **(∗ ∗ ∗) A Peculiar Gun**

A new bullet launcher is modelled as the picture shown below, where the bullet is a cylindrical wedge (shown in yellow) with mass $M = 2$kg, $\alpha = 30°$, and has a circular part with mass $m = 20$kg. The spring has a relaxed length $x_0 = 2$m and $k = 10^4$ N/m. The bullet is pushed down slowly, and then released, The spring can elongate to a maximum length of x_{max} before the circular part slips upon releasing. If $\mu_A = 0.2$, $\mu_B = 0.4$, $\mu_C = 0.3$, find x_{max}!

For exam practice the next line can be ignored, but nonetheless to make solving the equations easier, it is provided that slipping would happen on surfaces A and C.



8. **(∗) Telephone Pole**

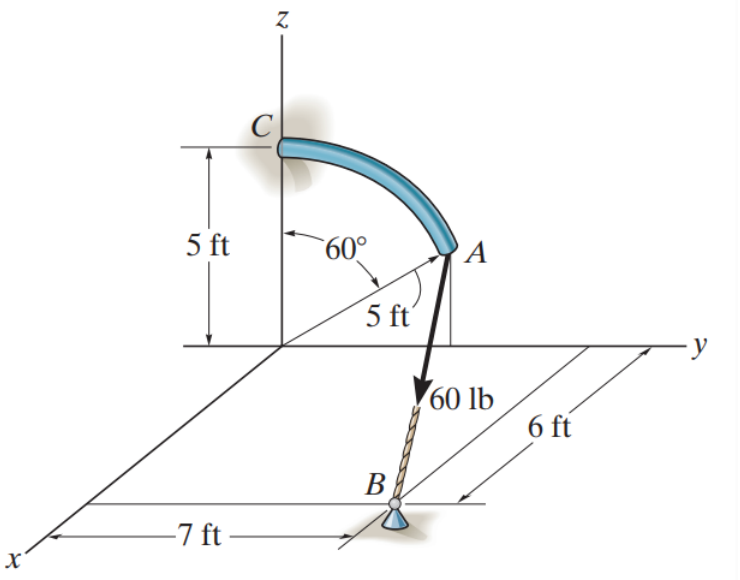
A telephone pole (base located at the origin) is under 700 lbs of compression from three cables. The cables are attached to the top of the tower, 40ft above its base, and are securely connected to the ground at (10, 10, 10) ft, (10, -20, 10) ft, and (-15, 10, -3) ft. Determine the tension in each cable.

(a) Draw a large, clear, free-body diagram for the body!

(b) Determine Cartesian component force equations of equilibrium for the body!

(c) Determine the values of tension in all four cables!

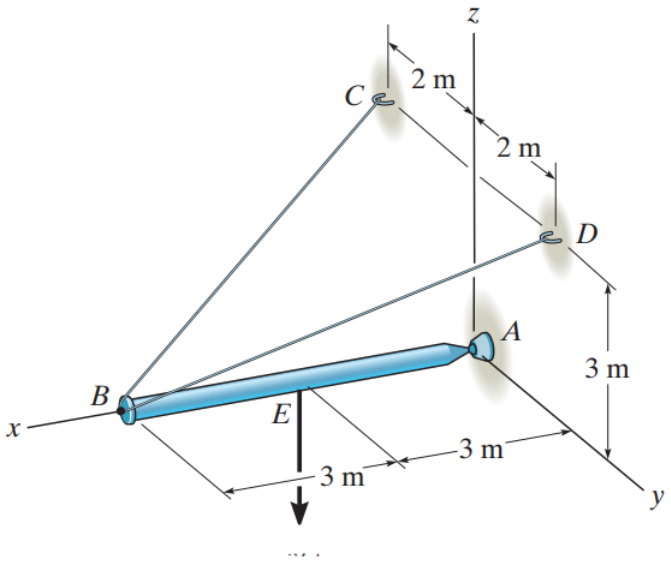
9. Determine the smallest force F that must be applied along the rope in order to cause the curved rod, which has a radius of 5 ft to fail at support C. This requires a moment of $M = 85$ lb $\cdot$ ft to be developed at C.
   Make sure to draw clear free body diagram of the system.



10. As shown in the diagram below, force of 600 N is applied on middle of the rod, point E.

    (a) Draw a large clear free body diagram of the given system.

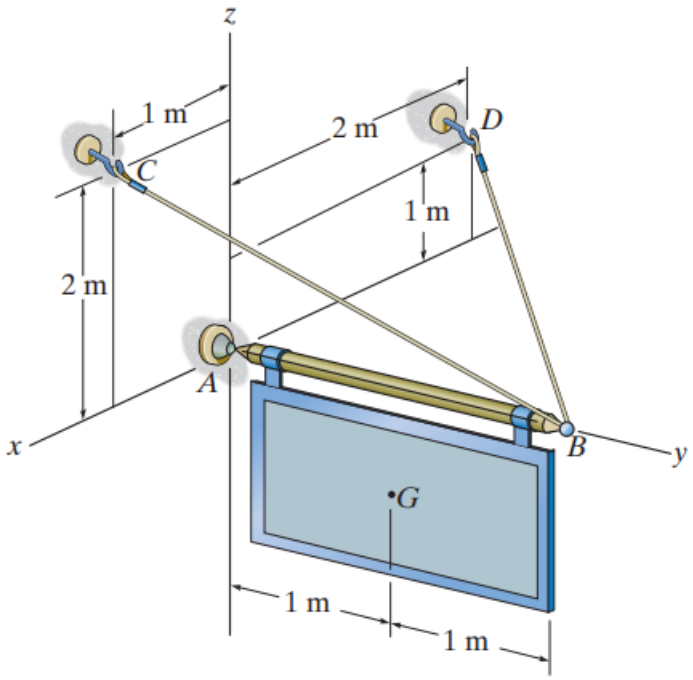
    (b) Determine the components of reaction at the ball-and-socket joint A and the tension in each cable necessary for equilibrium of the rod.



11. The sign has a mass of 100 kg with center of mass at G.

    (a) Draw clear and large free body diagram for given system.

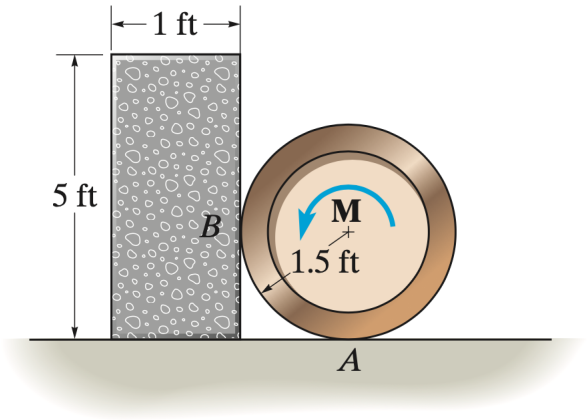
    (b) Determine x, y, and z components of reaction at the ball-and-socket joint A and the tension in wires BC and BD.



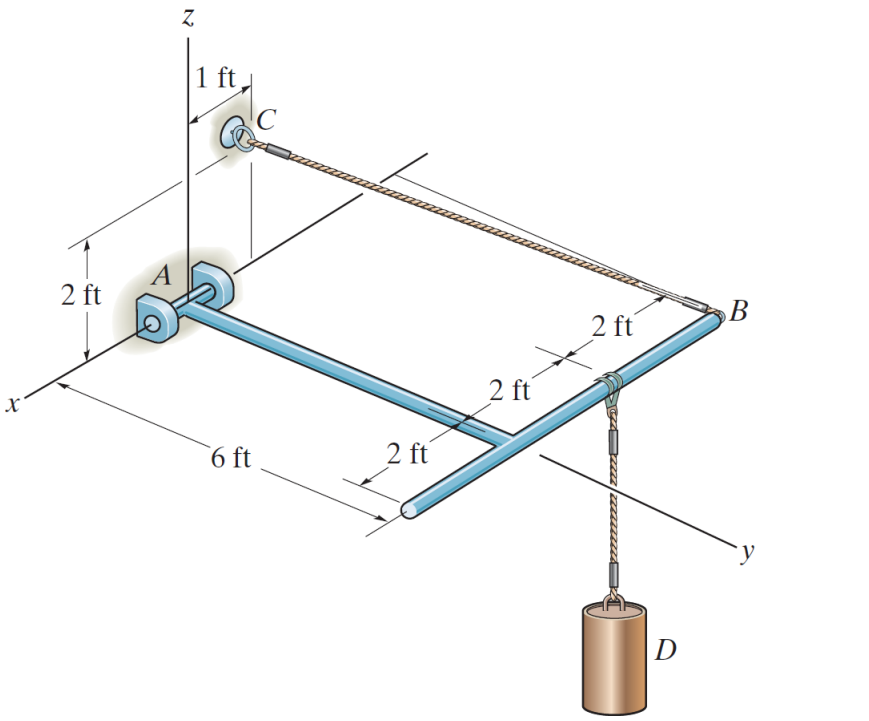
12. The uniform concrete block has a weight of 300 lb. The coefficients of static friction are $\mu_A = 0.2$, $\mu_B = 0.3$, and between the concrete block and the floor, $\mu = 0.4$.

    (a) Draw big and clear free body diagram.

    (b) Determine the smallest couple moment that can be applied to the 150-lb wheel that will cause impending motion.



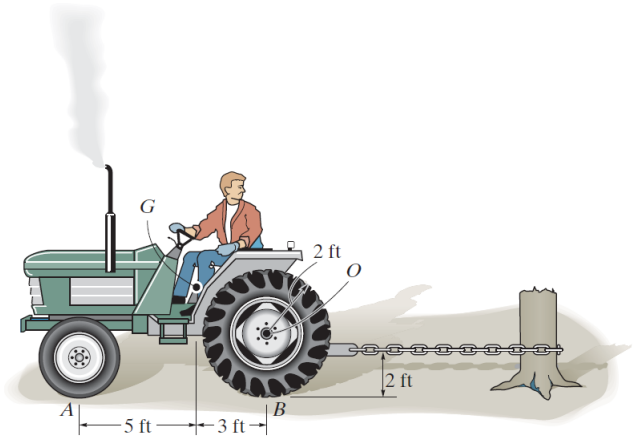
13. The member is supported by a pin at A and a cable BC. If the load at D is 300 lb determine the x, y, z components of reaction at the pin A and the tension in cable BC.



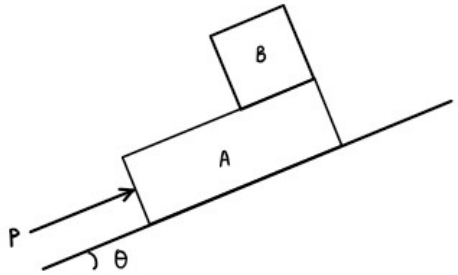
14. The tractor pulls on the fixed tree stump as shown below. The front wheels are free to roll. The tractor weighs 3500 lb and has a center of gravity at G. The coefficient of static friction between the rear wheels and the ground is $\mu_s = 0.5$.

    (a) Determine the torque that must be applied by the engine to the rear wheels to cause them to slip.

    (b) What coefficient of friction between the rear wheel and the ground is required for the front wheel to lift before the rear wheel slips?



15. The diagram below shows block A on an inclined plane with block B on block A. Block A is acted upon by a force P parallel to the plane. The mass of block A is 65 kg. The mass of block B is 15 kg. The magnitude of P is 700N. μ_k between A and B is 0.10 and μ_k between A and the plane is 0.30. The angle of the inclined plane is 30^o.



(a) Draw the free-body diagram for each block

(b) Determine the equations of motion for each block

(c) Solve these equations to determine the normal force of block A on block B, the normal force of the inclined plane on block A, and the acceleration of each block