GNG 1100 - ENGINEERING MECHANICS

Final Examination — Time: 3 hours
20 December 2003 —
Profs. Droste, Hallett, and Skaff

Closed Book. Non-programmable calculators only allowed. Free-body diagrams must be drawn wherever appropriate. Marks will be deducted for missing or incorrect free-body diagrams.

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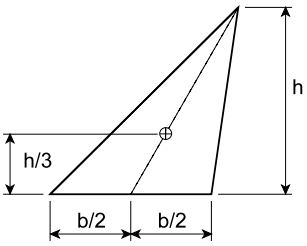
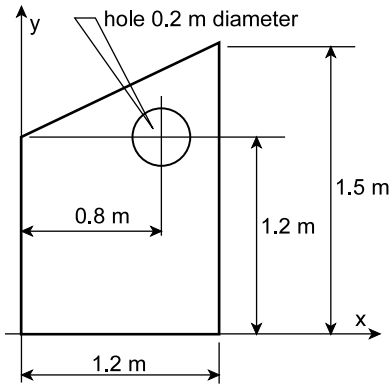
1. (6 marks) Determine the x and y coordinates of the centroid of the steel plate shown in the sketch. The location of the centroid of a triangle is shown in the diagram below.





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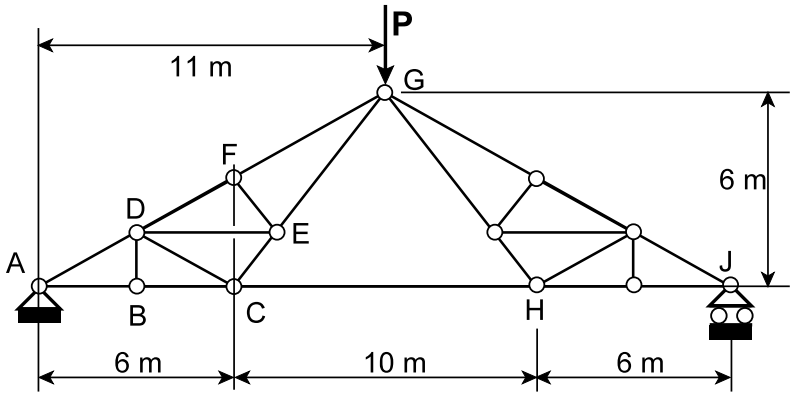
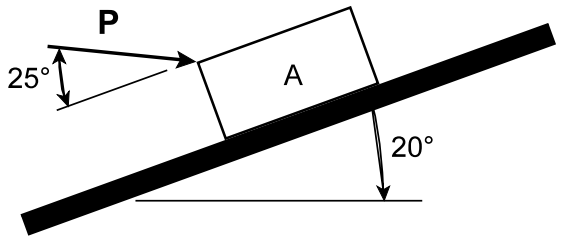


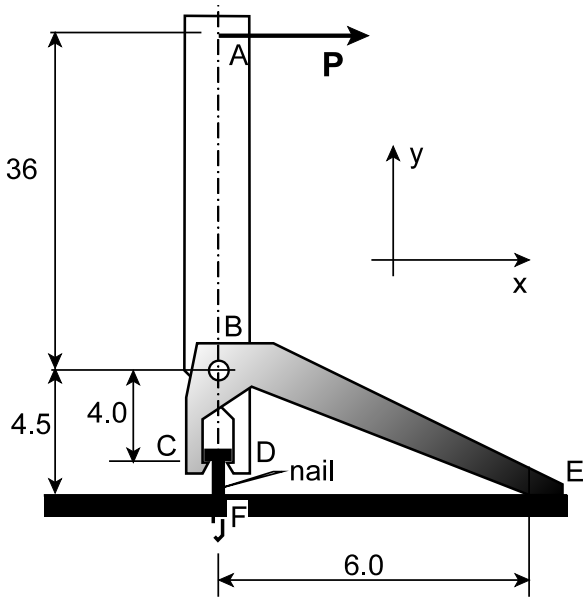
The truss shown is loaded by a force P = 16 kN. All joints are frictionless pins.
(a) (9 marks) Using the method of sections, determine the forces in members FG, EG and CH. Specifiy whether each is in compression or tension. **Do not** use the method of joints - a method of joints solution will receive a mark of zero (0).
(b) (1 marks) Identify all zero-force members in the left hand half of the truss.

3. (10 marks) A package with a mass of 30 kg is sliding down an incline with an initial velocity of 2.5 m/s. The coefficient of kinetic friction between the package and the incline is $\mu_K = 0.1$. A force P is applied starting at time t = 0 and is maintained at a constant value until the package comes to a stop. If it takes 5 seconds to stop the package, determine the magnitude of force P.

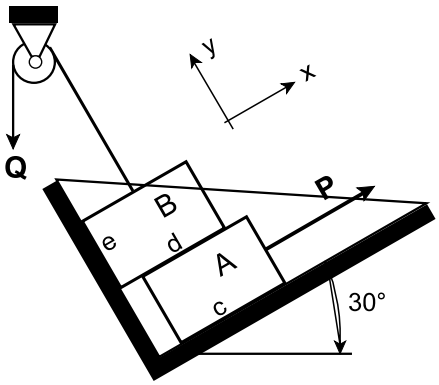


4. The sketch shows a tool used to pull out nails. There are two parts to the tool: the vertical lever ABD and the foot CBE, and they are joined by a frictionless pin at B. The nail is held tightly in the floor at F, and the tool grips and lifts the nail head at points C and D with horizontal and vertical components of force. All dimensions are in cm. To simplify the problem, you may assume:
- that the vertical components of force on the nail are equal ($C_Y = D_Y$), but the horizontal components are not ($C_X \neq D_X$);
- that the distance between points C and D is negligible, so that both C and D lie on a vertical line through B;
- that point E is a frictionless contact.

(a) (3 marks) Draw free-body diagrams of the two parts of the tool and of the nail.
(b) (9 marks) For an applied force P = 60 N, determine the forces exerted on the nail at C and D.



5. Two blocks are arranged as shown and acted on by forces **P** and **Q**. Block A weighs 300 N and block B weighs 200 N. The coefficient of static friction between all surfaces is $\mu_S = 0.3$, and the coefficient of kinetic friction between all surfaces is $\mu_K = 0.2$.

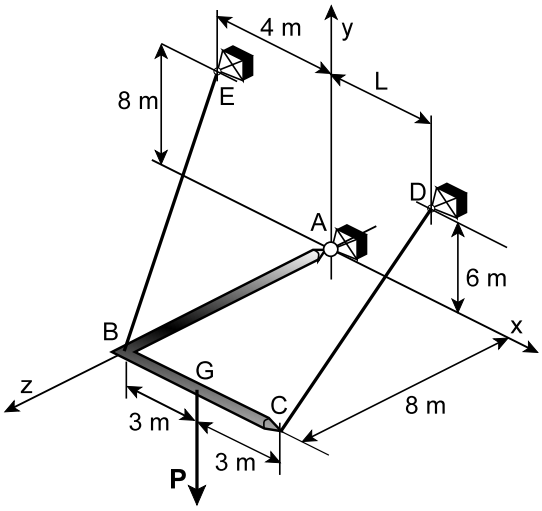


(a) (7 marks) If force Q = 0, determine the value of P if motion is impending. **Hint**: Since block B cannot move in the y-direction, there will not be a friction force at contact e. Assume that motion is *not* impending for block B.

(b) (2 marks) For part A above, *prove* that motion is not impending for block B.

(c) (1 mark) If an additional force Q is now applied in the direction shown, what will happen to block A and why? Assume that the force P which was calculated to cause impending slipping in (a) part is still applied. Answer in words - no calculations required.

6. A bent steel bar ABC of negligible weight is supported by two cables BE and CD and by a frictionless ball and socket joint A. It is loaded by force P = 5 kN. The supports D and E lie in the x-y plane, the bar lies in the x-z plane, and BC is parallel to the x axis.



(a) (3 marks) Write the forces in BE and CD as vector components. Note that F_{CD} will be a function of L.

(b) (9 marks) The distance L of point D from the y axis is variable, but there is only one position for which the bar will be in equilibrium in the position shown. Determine the value of L.

Total marks for this paper: 60