Second Semester Examination
2021/2022 Academic Session

July/August 2022

EMM 102 – Statics

Duration: 3 hours

INSTRUCTIONS:

Please check that this examination paper consists of **EIGHT (8)** pages including appendixes before you begin the examination.

Answer ALL **SIX (6)** questions.

Answer to each question must begin from a new page.

1. (a) The pipe assembly as shown in the figure is constructed to withstand forces applied at A, B and C. Determine the distance *b* between A and B so that the resultant couple moment has a magnitude of M_R = {m} Nm. Given that *a* is {a} cm and *c* is {c} cm.

m = 20-30, a = 30-40, c = 20-30

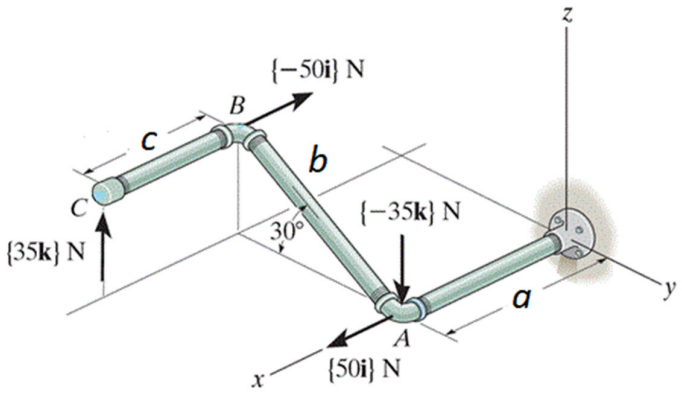


Figure Q1 (a)

(100 marks)

(b) The three vertical forces and a couple moment act on the pipe assembly as shown in the figure. If $\mathbf{F_1}$ and $\mathbf{F_2}$ are couple forces with a magnitude of {f} N, replace this force and couple moment system by an equivalent resultant force and couple moment acting at O. Express the results in Cartesian vector form. Given that ***P*** is {p} N, *a* is {a} m and *b* is {b} m.

f = 70-80, p = 160-200 a = 1.0-1.5, b = 0.5-1.0

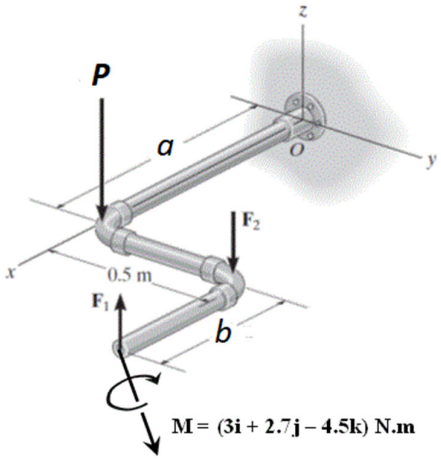


Figure Q1 (b)

(100 marks)

(c) Replace the force and couple moment system acting on the pipe assembly as shown in the figure by a resultant force and moment at point *O*. Express the results in Cartesian vector form. Given that *a* is {a} m, *b* is {b} m and *c* is {c} m.

a = 0.15-0.25, b = 0.20-0.30, c = 0.20-0.30

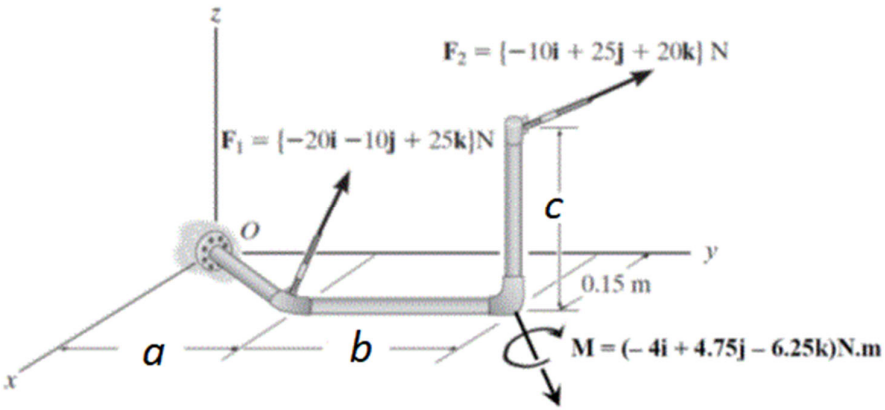


Figure Q1 (c)

(100 marks)

2. (a) The square plate shown in the figure has a mass of {m} kg and is supported by three vertical wires at A, B and C. A block is to be placed on the plate to achieve equal tensions in all three wires. Determine the location and weight of the lightest block that should be placed on the plate. Given that *a* is {a} cm, *b* is {b} cm and *c* is {c} cm.

m = 50-80, a = 10-12, b = 12-14, c = 14-20

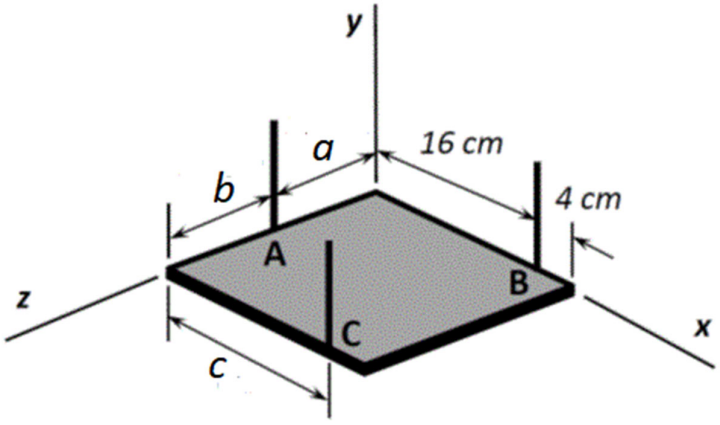


Figure Q2 (a)

(100 marks)

(b) A {m} kg steel beam is mounted to the vertical column using a welded pin at A as shown in the figure. The center of gravity of the steel beam is at G. To test the weld strength of the pin at A, a {w} kg man loads the beam by exerting a {f} N force on the rope which passes through a hole in the beam as shown in the figure. Calculate the reaction force and moment developed at pin A. Given that *a* is {a} cm and *b* is {b} cm.

m = 250-300, w = 60-90, f = 350-400, a = 110-140, b = 50-75

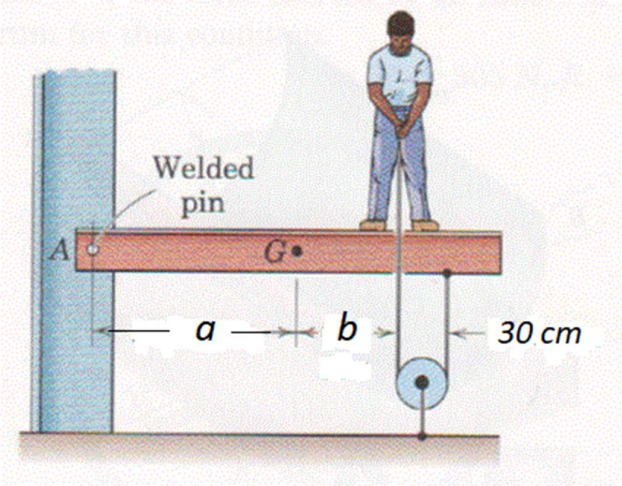
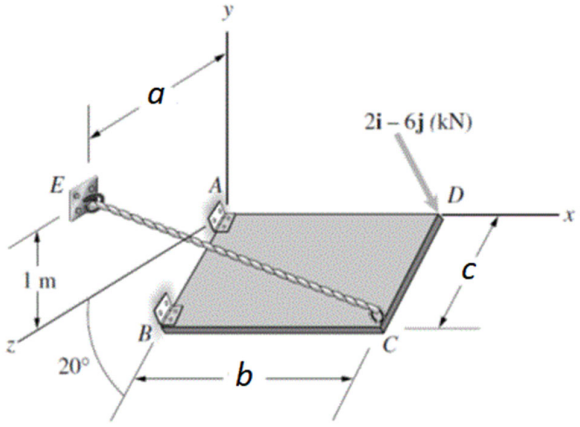


Figure Q2 (b)

(100 marks)

(c) The plate is supported by hinges at A and B, and a cable CE, and is loaded by a force at D, as shown in the figure. The edge of the plate to which the hinges are attached lies in the y-z plane. Assume that the hinges do not exert moment on the plate and the weight of the plate can be neglected, determine the tension in cable CE. Given that *a* is {a} m, *b* is {b} m and *c* is {c} m.

a = 2.8-4.0, b = 1.8-2.5, c = 2.0-3.5



(100 marks)

3. (a) Beam AD is illustrated as in Figure 3. Wedge C is situated under AD beam at point A. Given that at the top and bottom surfaces of the Wedge C, the coefficients of static friction are μ_{CA} = {a} and μ_{CB} = {b} respectively. By neglecting wedge's weight and size, and the beam's thickness:

(i) Determine the horizontal force P needed by wedge C to lift it out from beneath the beam AD.

(80 marks)

(ii) Determine whether the wedge is self-locking when P=0.

(20 marks)

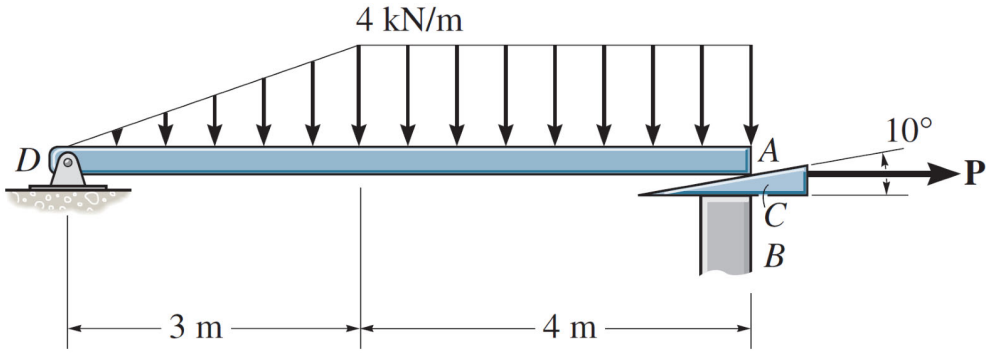


Figure 3

4. The truss which is attached to a wall is subjected to the indicated loadings as shown in Figure 4. Set P as {c} kN. By using a joint method, determine the force in all members. Indicate whether the members are in tension or compression. Draw free body diagram at each joint.

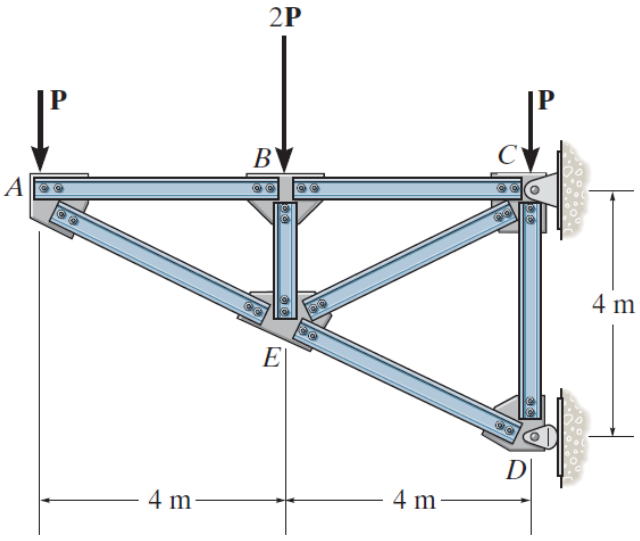


Figure 4

(100 marks)

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5. (a) Determine the $\bar{x}$, $\bar{y}$, and $\bar{z}$ of the coordinates of the mass center of the fixture formed from thin metal plate of uniform thickness as shown in Figure 5.

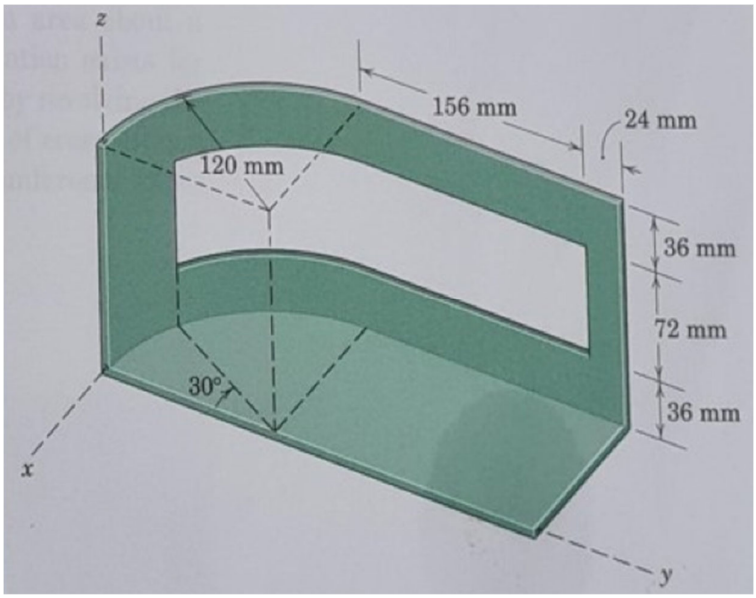
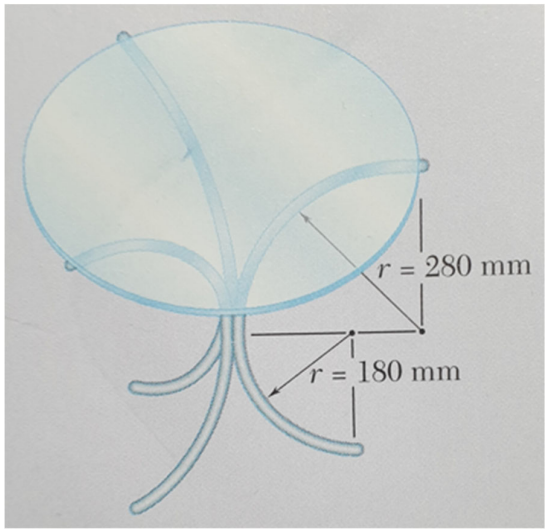


Figure 5

(100 marks)

(b) The three legs of a small glass-topped table are equally spaced and are made of steel tubing that has an outside diameter of 24 mm and a cross sectional area of 150 mm^2. The diameter and the thickness of the table top are 600 mm and 10 mm, respectively. Knowing that the density of the steel is 7860 kg/m^3 and of glass is 2190 kg/m^3, locate the center of gravity of the table.



(100 marks)

6. (a) A rigid bar AB is hinged at A and supported by two vertical wires attached at points C and D (as shown in Figure 6). Both wires have the same cross-sectional area of 16 mm^2 and are made of the same material (modulus E = 200 GPa). Given that h = 0.4 m, c = 0.5 m and d = 1.2 m.

i. Sketch a free body diagram and determine the tensile stresses in both wires due to the load P = 970 N acting at end B of the bar.

ii. Determine the downward displacement at end B of the bar.

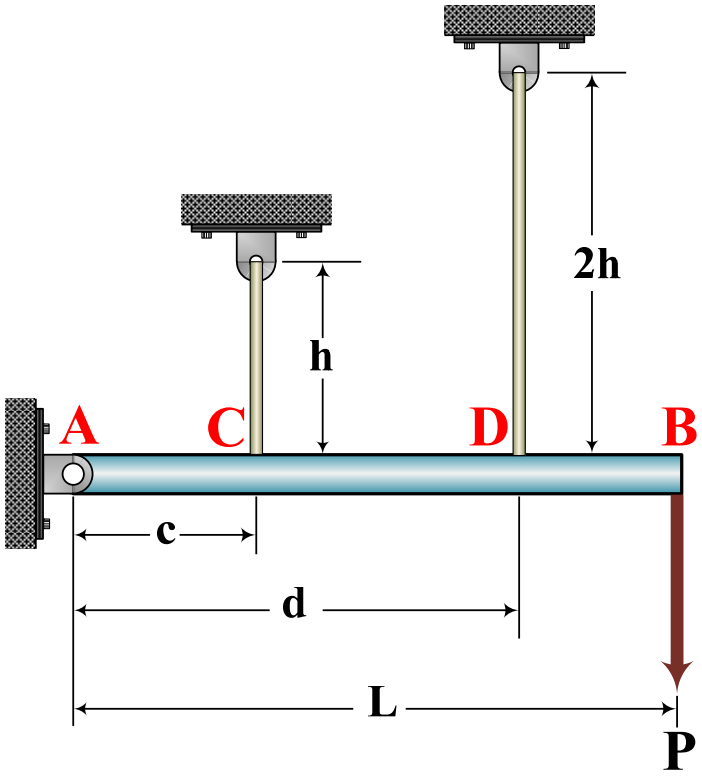


Figure 6

(100 marks)

(b) A horizontal rigid beam ABC is supported by two vertical bars BD and CE. The cross sectional areas of bars BD and CE are 1020 mm^2 and 520 mm^2 , respectively. The bars are made of steel with a Young's Modulus of 205 GPa. Given:

x = {450} mm
y = {225} mm
z = {120} mm
m = {480} mm
n = {600} mm

i. Sketch a free body diagram and calculate the maximum allowable load P if the displacement of point A is limited to 1.0 mm.

ii. If P = 25 kN, what is the required cross sectional area of bar CE so that the displacement at point A is equal to 1.0 mm.

(Please note that the figure is not drawn to scale).

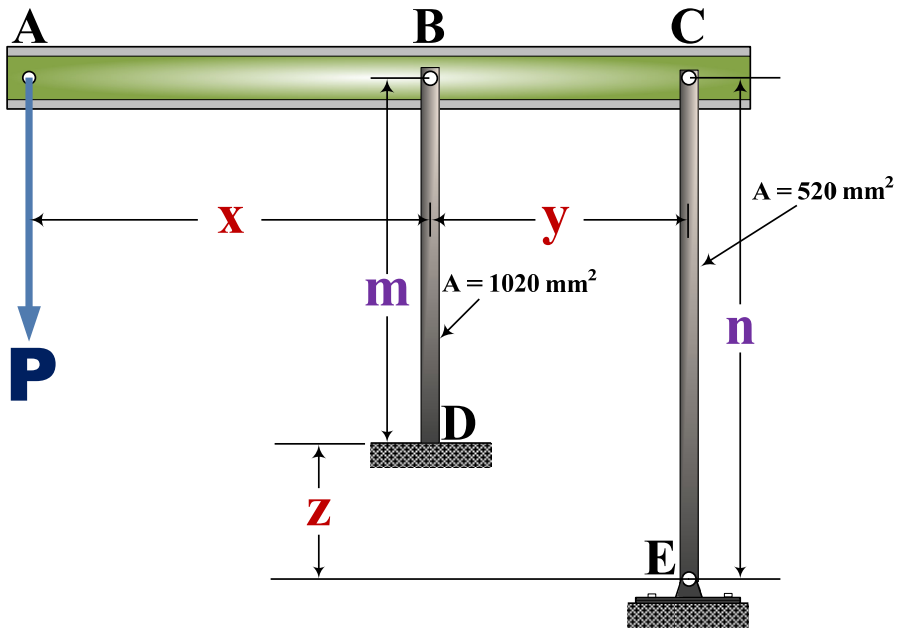


Figure 6

(100 marks)

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