Gebze Technical University
Department of Mechanical Engineering

# ME 231 - Statics

Fall 2024, Mid-term exam #1
07 November 2024

**Time Allowed:** 160 minutes

**Attention!**

- Please read carefully before you start answering the questions.
- Books or notes are not allowed. You can use calculators.
- You are not allowed to leave the exam for any reason, before handing in the exam sheet.
- Show all the details of your answer including **free body diagrams**. You will be penalized for unsystematic or unclear solutions.

| Full name | Student No. | Q1 | Q2 | Q3 | Q4 | Q5 | Total |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

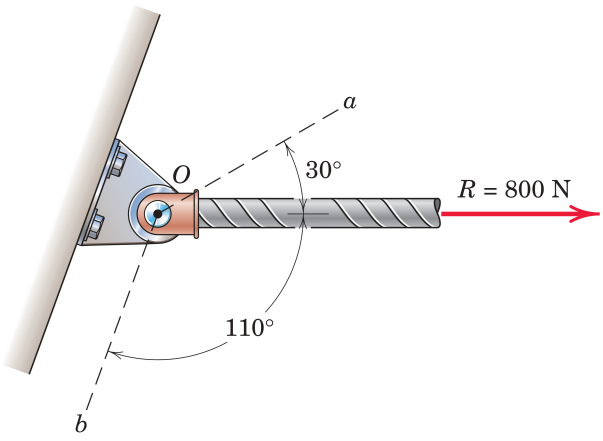
*Good luck, Saeed Lotfan*

**Question 1: (20%)**
The pin support shown below is connected to a wall by four similar bolts (only two visible and two on the other side).

**a.** By using geometric method, and drawing the appropriate parallelogram, find the scalar components $R_a$ and $R_b$ of the 800 N force along axes $a$ and $b$. (10%)

**b.** Calculate the scalar projection of the 800 N force onto the axis $a$. If we consider this projection as one of the components of the 800 N force, what will be the other component's scalar value and direction? (10%)

**Solution 1:**

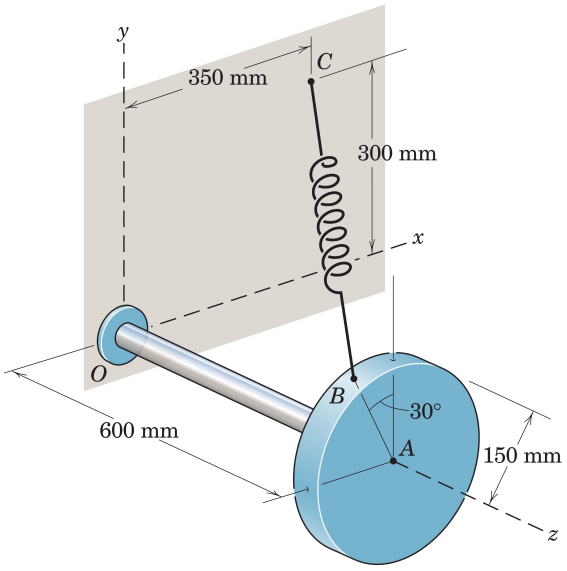


**Question 2: (20%)**
A cantilever bar of length 600 mm is holding a disk of radius 150 mm. The spring which connects point B of the disk and point C on the vertical surface is under a tension of 500 N. Moreover, the disk has a weight of 50 N acting at point A.

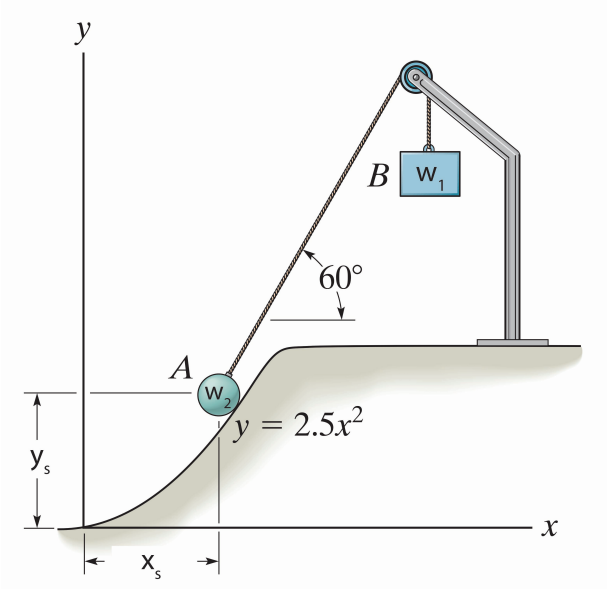
**a.** Write the tension in spring as it acts on point B as a force vector **T** in terms of the unit vectors **i**, **j**, and **k**. (8%)

**b.** Replace the **T** force and weight **W** acting on the disk by resultant force $\mathbf{F}_R$ and moment $\mathbf{M}_R$ at point O. (12%)

**Solution 2:**



**Question 3: (20%)**
A 40 N sphere rests on the smooth parabolic surface and is held by a crate of weight 30 N. Determine the normal force it exerts on the surface and the equilibrium position $(x_s, y_s)$.
**Solution 3:**

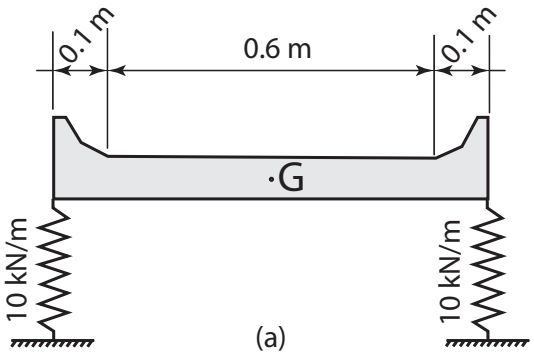


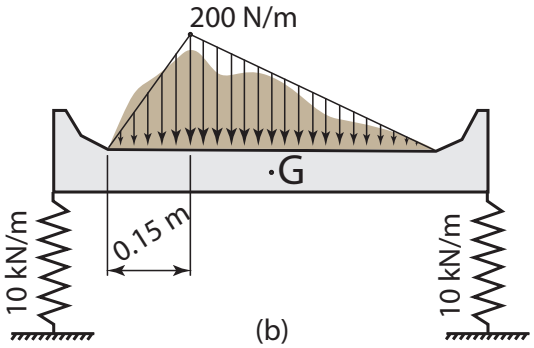
**Question 4: (20%)**
A beam-like container is placed on a foundation of two springs each with stiffness of 10 kN/m as shown in Figure (a). The container is homogeneous such that its weight 40 N is acting on its geometric center at point G.

**a.** For the equilibrium condition at Figure (a), find the deformation in each spring. (6%)

**b.** If soil is placed on the container as shown in Figure (b). The weight of the added soil can be approximated by a distributed load as shown. In this condition, find the deformation in each spring. (14%)

**Solution 4:**



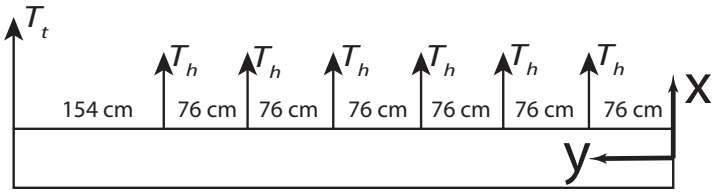
**Question 5: (20%)**

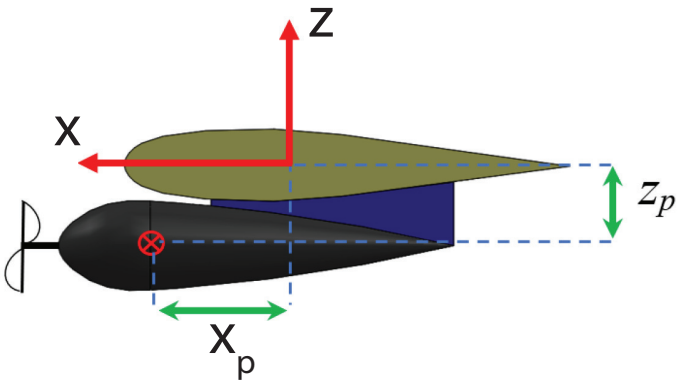
An electric aircraft with distributed electric propulsors is shown in the Figure. The configuration is similar to the wing of the NASA's X-57 "Maxwell" aircraft. There are six high-lift motors of weight 100 N and one tip propulsor of weight 260 N all mounted on the wing. The wing has weight per unit length of 357 N/m The motors are distributed in the $y$ direction along the wing, and the position of the mass center of each motor is denoted by $x_p$ and $z_p$, in the x and z directions, respectively. The origin of the coordinate system is located at the root of the wing. It is assumed that the thrust of each high-lift engine is $T_h = 400\,\text{N}$ and the thrust of the tip propulsor is $T_t = 2507\,\text{N}$.

**a.** Find all the reaction forces $R_x$, $R_y$, and $R_z$ at the root of the wing where the coordinate system is attached. (6%)

**b.** Find all the reaction moments $M_x$, $M_y$, and $M_z$ at the root of the wing where the coordinate system is attached as functions of $x_p$ and $z_p$. Note that for the high-lift motors $x_p$ and $z_p$ are shown in figure. However, for the tip motor $z_p = 0$ and $2x_p$ is the distance in the x direction. (14%)

**Solution 5:**

For solutions:

Gebze Technical University
Department of Mechanical Engineering

# ME 231 - Statics

Fall 2024, Mid-term exam #2
12 December 2024

**Time Allowed:** 160 minutes

**Attention!**

- Please read carefully before you start answering the questions.
- Books or notes are not allowed. You can use calculators.
- You are not allowed to leave the exam for any reason, before handing in the exam sheet.
- Show all the details of your answer including **free body diagrams**. You will be penalized for unsystematic or unclear solutions.

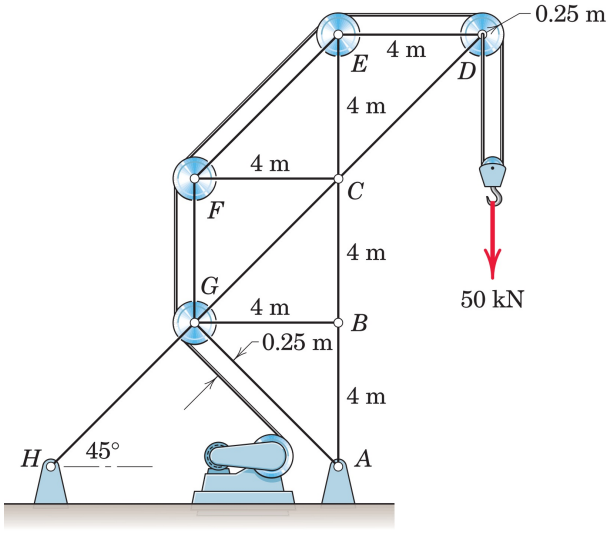
| Full name | Student No. | Q1 | Q2 | Q3 | Q4 | Q5 | Total |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

*Good luck, Saeed Lotfan*

**Question 1: (20%)**

The electrical motor is on the verge of lifting a 50 kN weight by the help of a truss structure. The coefficient of static friction between the rope and the surfaces of all large pulleys (excluding the pulley of the hook) is given as $1/\pi$. Using the method of sections, determine the forces in the members $FG$, $CG$, and $CB$. Clearly indicate whether each member is in tension or compression.

**Solution 1:**

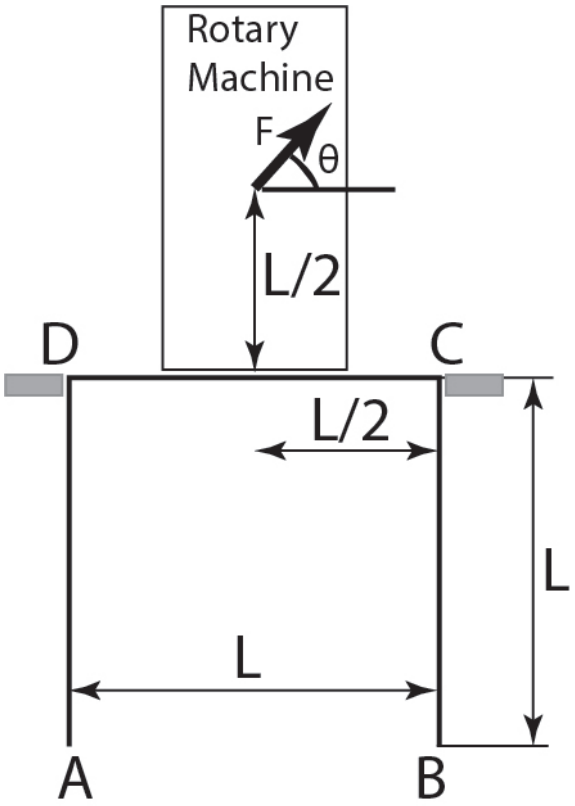


**Question 2: (20%)**
A rotary machine is mounted on a table, as shown. The machine has a defect that generates an unbalanced force $F$, which rotates, continuously changing its direction with the angle $\theta$. The table is positioned on a frictionless floor, with its lateral motion constrained by walls at points $C$ and $D$, preventing movement to the left or right.

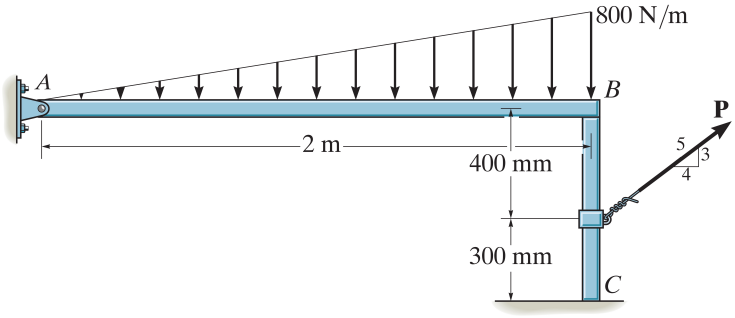
**a.** Determine the changes in reactions at supports $A$, $B$, $C$, and $D$ as functions of the unbalanced force $F$ and its angle of rotation $\theta$, where $\theta$ varies from 0° to 180°. (15%)

**b.** Illustrate the variation of the reactions as functions of the angle $\theta$ for $0° \leq \theta \leq 180°$. Ensure each diagram is clearly labeled to indicate the corresponding reaction force. (5%)

**Solution 2:**



**Question 3: (20%)**
The beam $AB$ has a negligible mass and thickness and is subjected to a triangular distributed loading. It is supported at one end by a pin and at the other end by a post having a mass of 50 kg and negligible thickness. Determine the minimum force $P$ needed to move the post. The coefficients of static friction at $B$ and $C$ are $\mu_B = 0.4$ and $\mu_C = 0.2$, respectively.
**Solution 3:**

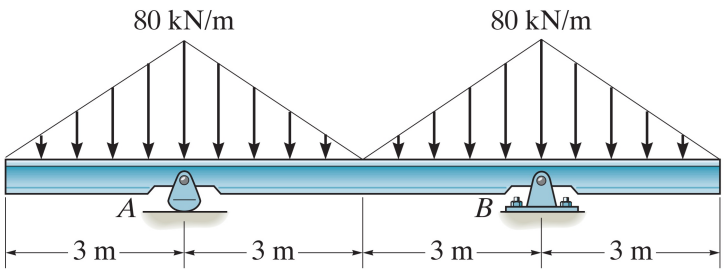


**Question 4: (20%)**
An overhanging beam is under distributed load as shown.

**a.** Determine the functions of internal shear and moment for $0 \leq x \leq 6$. (12%)

**b.** Draw the shear and moment diagrams for the beam for $0 \leq x \leq 12$. (8%)

**Solution 4:**

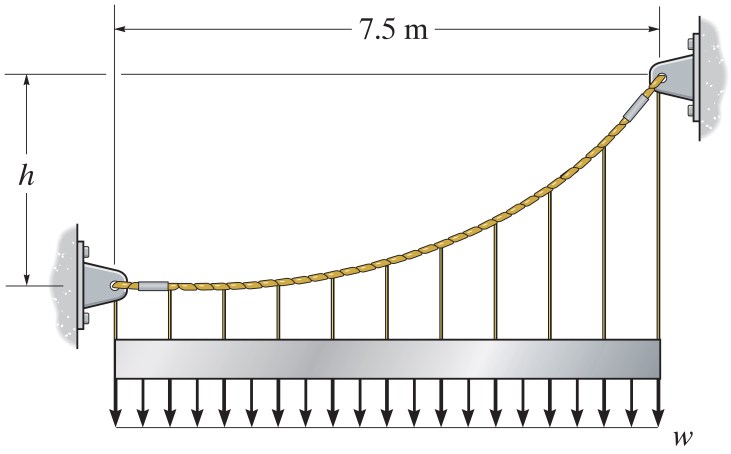


**Question 5: (20%)**
The cable is holding a uniform weigth of 1 kN/m as shown. For $h = 6\,\text{m}$:

**a.** Determine the maximum tension inside the cable. (10%)

**b.** Find expressions for internal shear, moment, and tension inside the cable and draw them as functions of $x$. (10%)

**Solution 5:**



For solutions:

Gebze Technical University
Department of Mechanical Engineering

# ME 231 - Statics

Fall 2024, Final Exam
9 January 2025

**Time Allowed:** 160 minutes

**Attention!**

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| Full name | Student No. | Q1 | Q2 | Q3 | Q4 | Q5 | Total |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

*Good luck, Saeed Lotfan*

**Question 1: (20%)**

The frame ABC, that is in static equilibrium, is loaded as shown below by two point forces, a distributed force and a (couple) moment. The frame is free at points A and B, while fixed at point C.

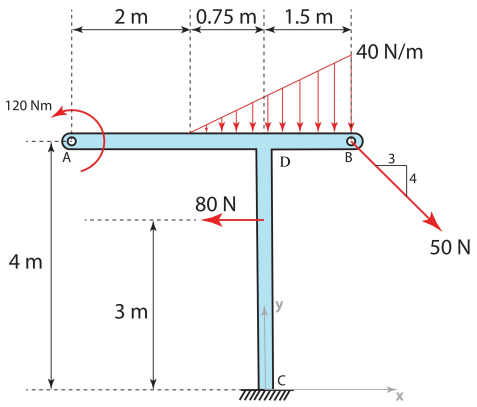
**a.** Determine the equivalent force, $F_{eq}$, for the distributed loading (please specify its magnitude and distance from point B). (3%)

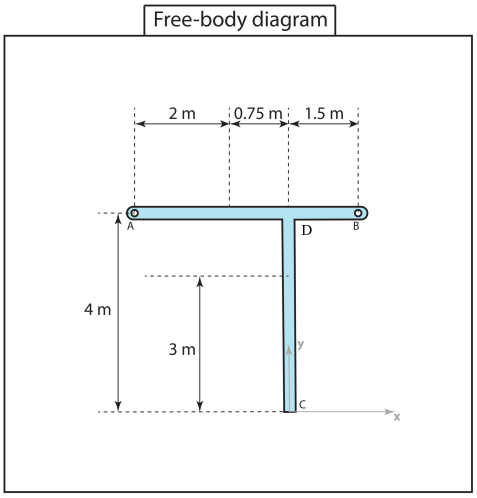
**b.** Draw the free body diagram for the frame ABC on the diagram shown. (4%)

**c.** Find the reactions in vector form at the fixed support at point C. (9%)

**d.** Draw internal normal loading diagrams for part AB and CD of the frame, respectively. (4%)

**Solution 1:**



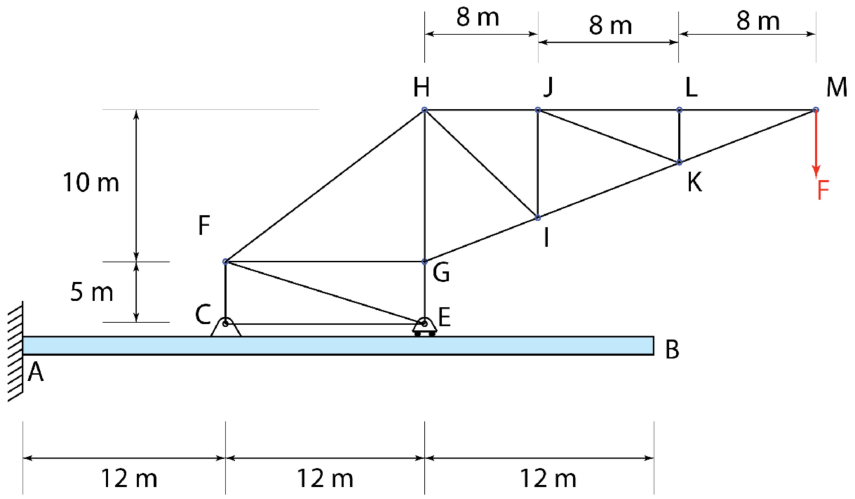
**Question 2: (20%)**
For the system shown below, which is under a point force of 40 kN,

**a.** Determine all zero-force members of the truss structure. (4%)

**b.** Determine all reaction forces at C, E, and A. (12%)

**b.** Draw shear and moment diagrams for the beam, without obtaining the equations. (4%)

**Solution 2:**

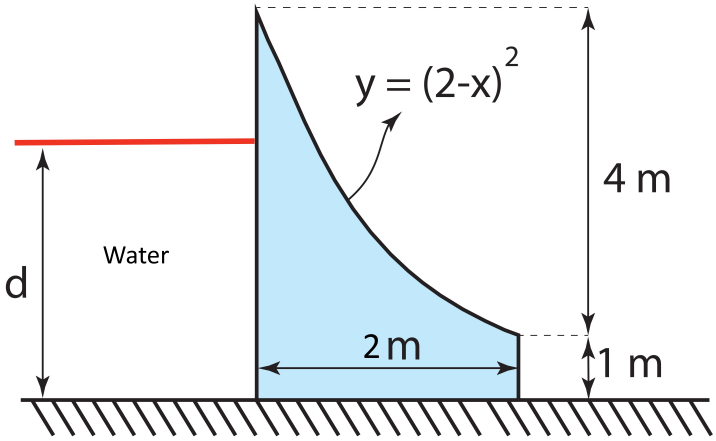


**Question 3: (20%)**
An obstacle of 7000 kg is holding against water on a surface with a friction coefficient of $\mu_s = 0.62$. The obstacle has a width of 2 m (perpendicular to the page).

**a.** Determine the center of gravity for the obstacle. For the solution procedure, first divide the area into the parabolic part and the rectangular part, then calculate centroids for each, and finally obtain the centroid for the whole geometry. (10%)

**b.** If water has a density of 1000 kg/m$^3$, and $g$ is approximated by 10 m/s$^2$, find the range of $d$ for no impending motion, and discuss whether slipping or tipping occurs first as we increase the height of water. Also, clearly state how the position of the ground normal reaction force changes as $d$ is increased from a zero value (no water). (10%)

**Solution 3:**

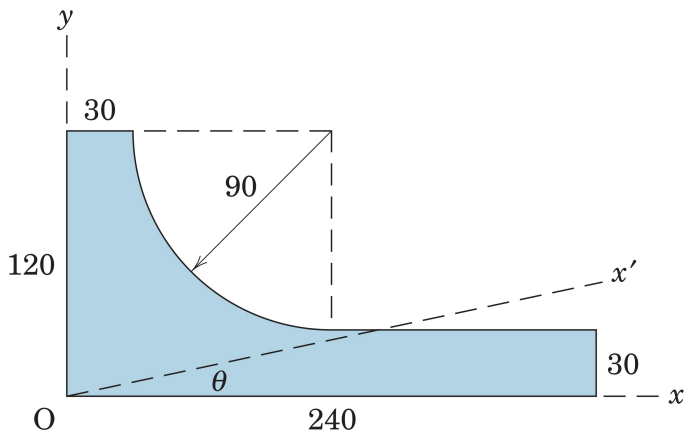


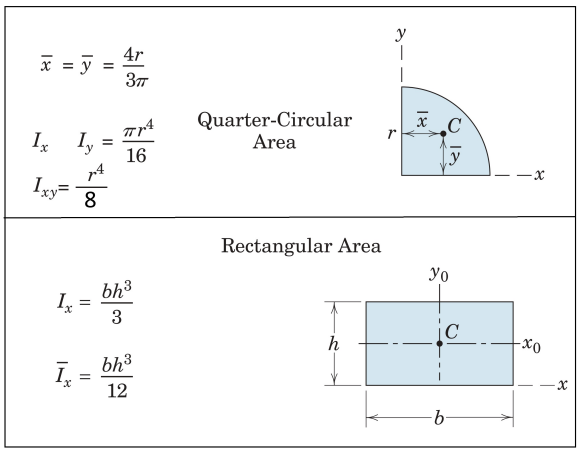
**Question 4: (20%)**
For the shaded area shown below:

**a.** Determine the moments of inertia about the $x$ and $y$ axes, *i.e.*, $I_x$ and $I_y$, as well as the product of inertia $I_{xy}$. Dimensions are given in mm. (12%)

**b.** Draw Mohr's circle, and find the maximum and minimum values for the moments of inertia as well as the angle $\theta$ at which these maximum and minimum values occur. (8%)

**Solution 4:**



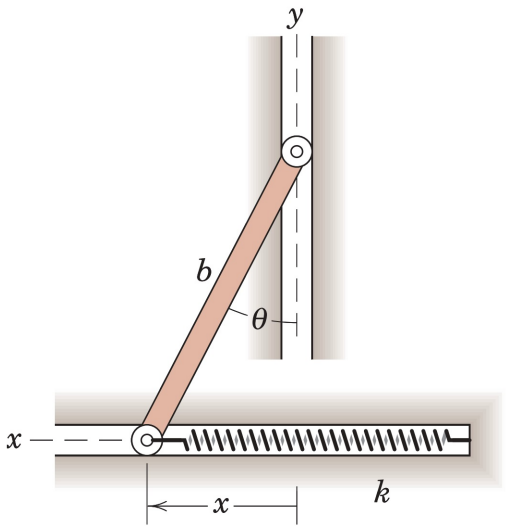



**Question 5: (20%)**
The ends of the uniform bar of mass $m$ slide freely in the horizontal and vertical guides. The spring of stiffness $k$ is undeformed when $x = 0$.

**a.** By using the virtual work method find two conditions of equilibrium for the system. (12%)

**b.** Investigate the stability of these equilibrium conditions via potential energy method, if $mg = \sqrt{2}kb$. (8%)

**Solution 5:**



For solutions:

# Gebze Technical University

Department of Mechanical Engineering

## ME 231 - Statics

Fall 2023, Mid-term exam #1

16 November 2023

**Time Allowed:** 135 minutes

**Attention!**

- Please read carefully before you start answering the questions.
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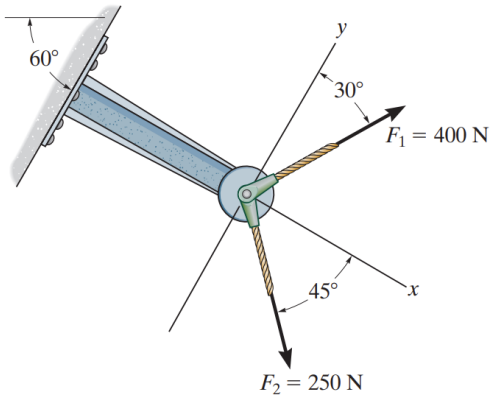
| Full name | Student No. | Q1 | Q2 | Q3 | Q4 | Q5 | Total |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

*Good luck, Saeed Lotfan*

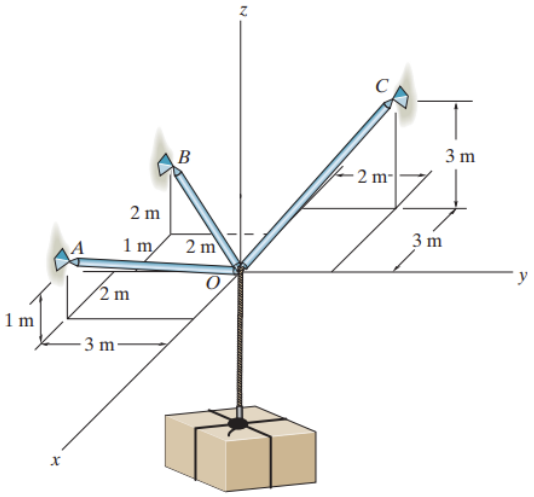
**Question 1: (15%)**

The support shown below is connected to a wall by six similar bolts. How should the angle 30° change, such that the reaction forces in these bolts be equal to each other. Please use geometric method in your solution and state the value of force in each bolt.

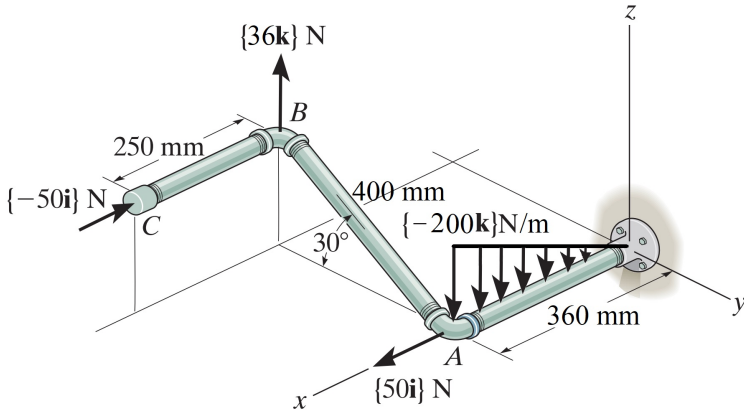
**Solution 1:**



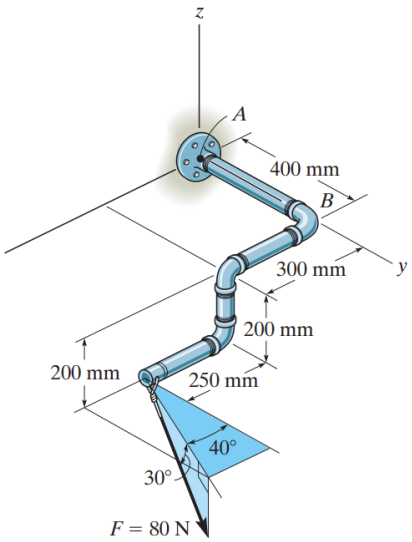
**Question 2: (25%)**
If the maximum force in each rod can not exceed 1500 N, determine the greatest mass of the crate that can be supported. The rods are weightless and the supports are pins. Please use Cartesian vector formulation in your solution. ($g = 9.81$ m/s$^2$)
**Solution 2:**



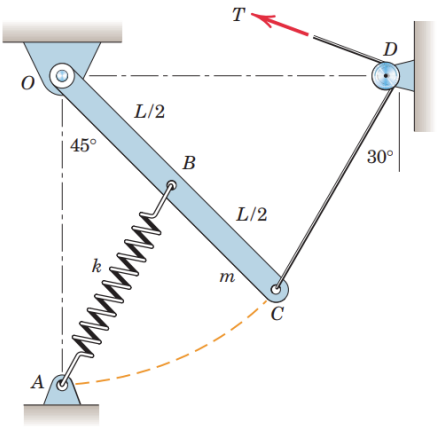
**Question 3: (20%)**
For the pipe assembly shown below,
**a.** Express the resultant couple moment of the exerted forces in the Caresian vector form.
**b.** Calculate the moment that is produced along the pipe AB.
**Solution 3:**



**Question 4: (25%)**
For the pipe assembly shown below, all pipes have a mass per unit length of 1 kg/m, with assuming ($g = 10$ m/s$^2$);
**a.** Replace all loading by an equivalent resultant force and couple moment at point O.
**b.** Determine the angle $\theta$ between the resultant force and couple moment in part **a**.
**Solution 4:**



**Question 5: (15%)**
The uniform bar $OC$ of length L pivots freely about a horizontal axis through $O$. If the spring of modulus $k$ is unstretched when $C$ is coincident with $A$, determine the tension $T$ required to hold the bar in the position shown as a function of $m$ and $k$. The diameter of the small pulley at $D$ is negligible.
**Solution 5:**



# Gebze Technical University

Department of Mechanical Engineering

## ME 231 - Statics

Fall 2023, Mid-term exam #2

21 December 2023

**Time Allowed:** 150 minutes

**Attention!**

- Please read carefully before you start answering the questions.
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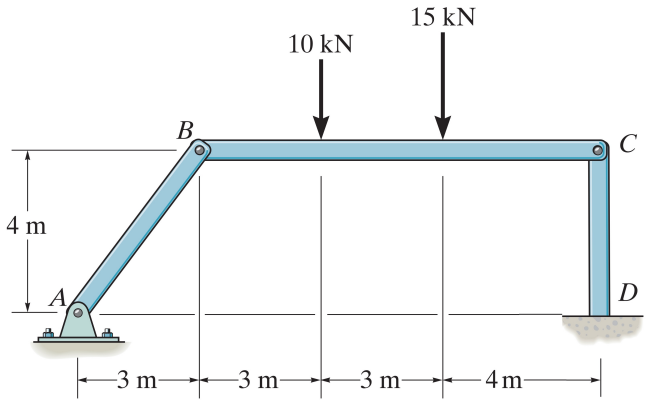
| Full name | Student No. | Q1 | Q2 | Q3 | Q4 | Q5 | Total |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

*Good luck, Saeed Lotfan*

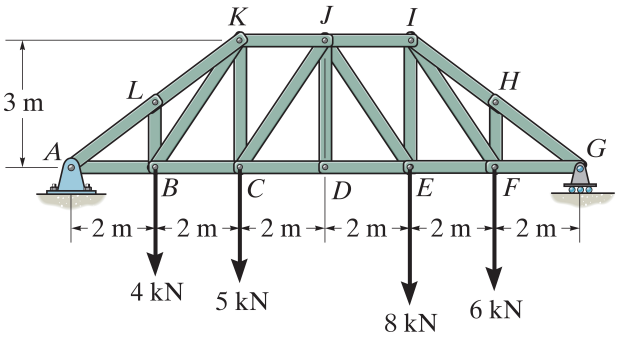
**Question 1: (16%)**

Three weightless bars are attached to each other by pins at points $B$ and $C$. This frame is under two loads as shown and pinned and welded to ground respectively at $A$ and $D$. Find all reaction loadings at $D$. (All pins are friction-less)

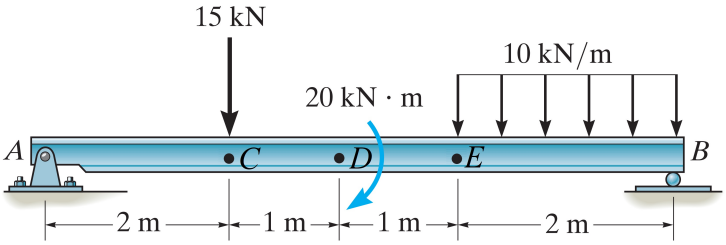
**Solution 1:**



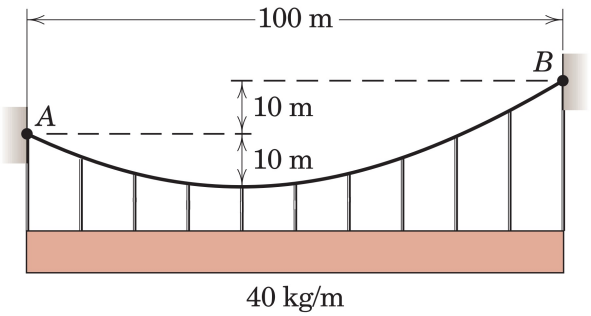
**Question 2: (20%)**
For the truss shown below; **a.** Determine all zero force members. **b.** Using the method of sections, determine the force in members $JI$, $JE$, and $DE$ and state if the members are in tension or compression. (Ignore friction, $A$ is a pin, and $G$ is a roller support)
**Solution 2:**



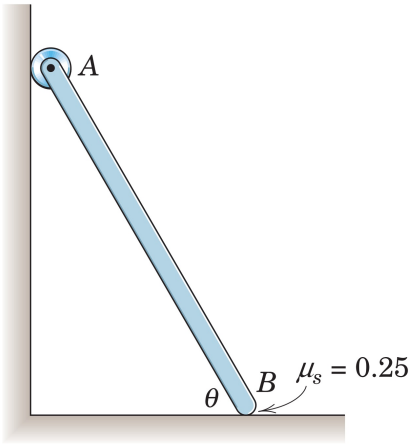
**Question 3: (20%)**
For the simply supported beam shown below, draw the internal shear and moment diagrams.
**Solution 3:**



**Question 4: (24%)**
A cable supports a load of $40(9.81)\,\mathrm{N/m}$ uniformly distributed along the horizontal and is suspended from two fixed points $A$ and $B$ located as shown.
**a.** By defining the coordinate system $x - y$ at the minimum point of the cable where $dy/dx = 0$, calculate the shape of the cable as $y(x) = kx^2$.
**b.** Calculate the tension at point $B$.
Hint: In addition to boundary conditions $y(0)$ and $dy(0)/dx$ to find the unknowns, also use the ratio $y(x_B)/y(x_A)$ to find the horizontal tension in the cable.
**Solution 4:**



**Question 5: (20%)**
The uniform slender bar of mass $m$ and length $l$ has an ideal roller at its upper end $A$. If the coefficient of static friction at $B$ is $\mu_s = 0.25$, determine the minimum angle $\theta$ for which equilibrium is possible.
**Solution 5:**



# Gebze Technical University

Department of Mechanical Engineering

## ME 231 - Statics

Fall 2023, Final Exam
22 January 2024

**Time Allowed:** 150 minutes

**Attention!**

- Please read carefully before you start answering the questions.
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| | | | | | | | |

*Good luck, Saeed Lotfan*

**Question 1: (20%)**

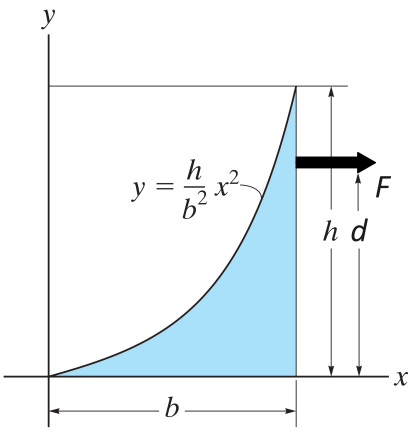
A parabolic shaped box of 60 kg is on a rough surface shown by $x$ axis. The box is pulled by a force as shown.

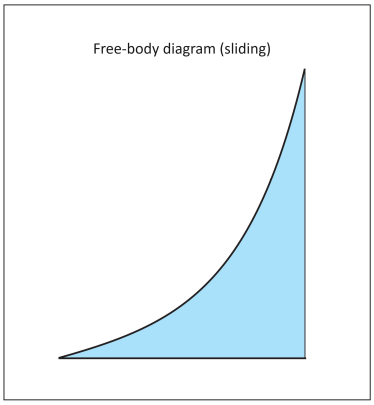
**a.** Find the mass center of the box.

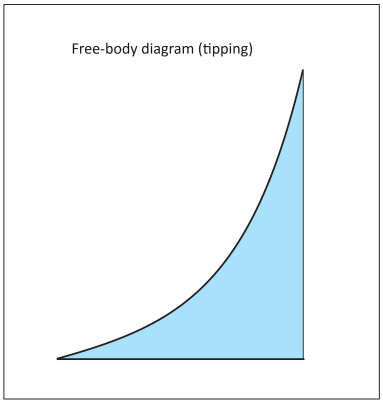
**b.** Draw free-body diagrams of the box at impending motion for two cases of only sliding and only tipping.

**c.** For $d = 3b/4$, if we keep increasing the applied force, will the box first begin to slide or tip over?

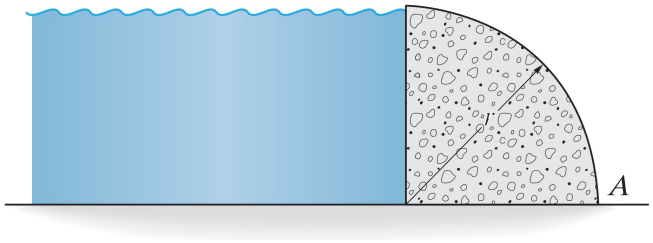
**Solution 1:**



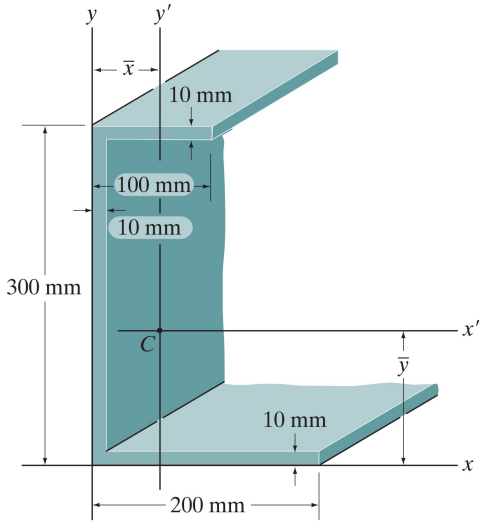



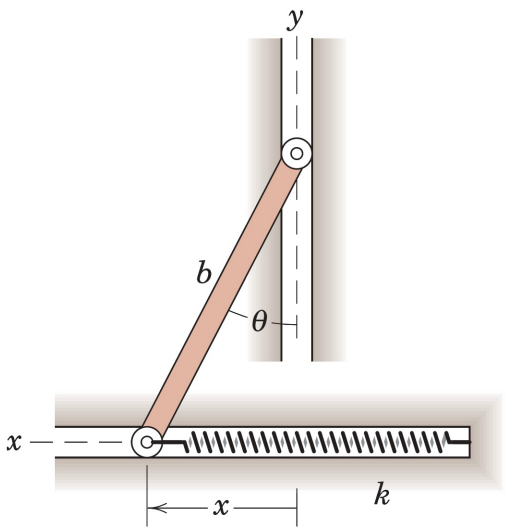
**Question 2: (15%)**
The quarter circular "gravity" dam is held in place by its own weight.
**a.** Draw the free body diagram of the dam.
**b.** Determine the smallest possible density of the material composing the dam so that it will be prevented from overturning about its end $A$. $\rho_w = 1000\text{kg/m}^3$.
**Solution 2:**



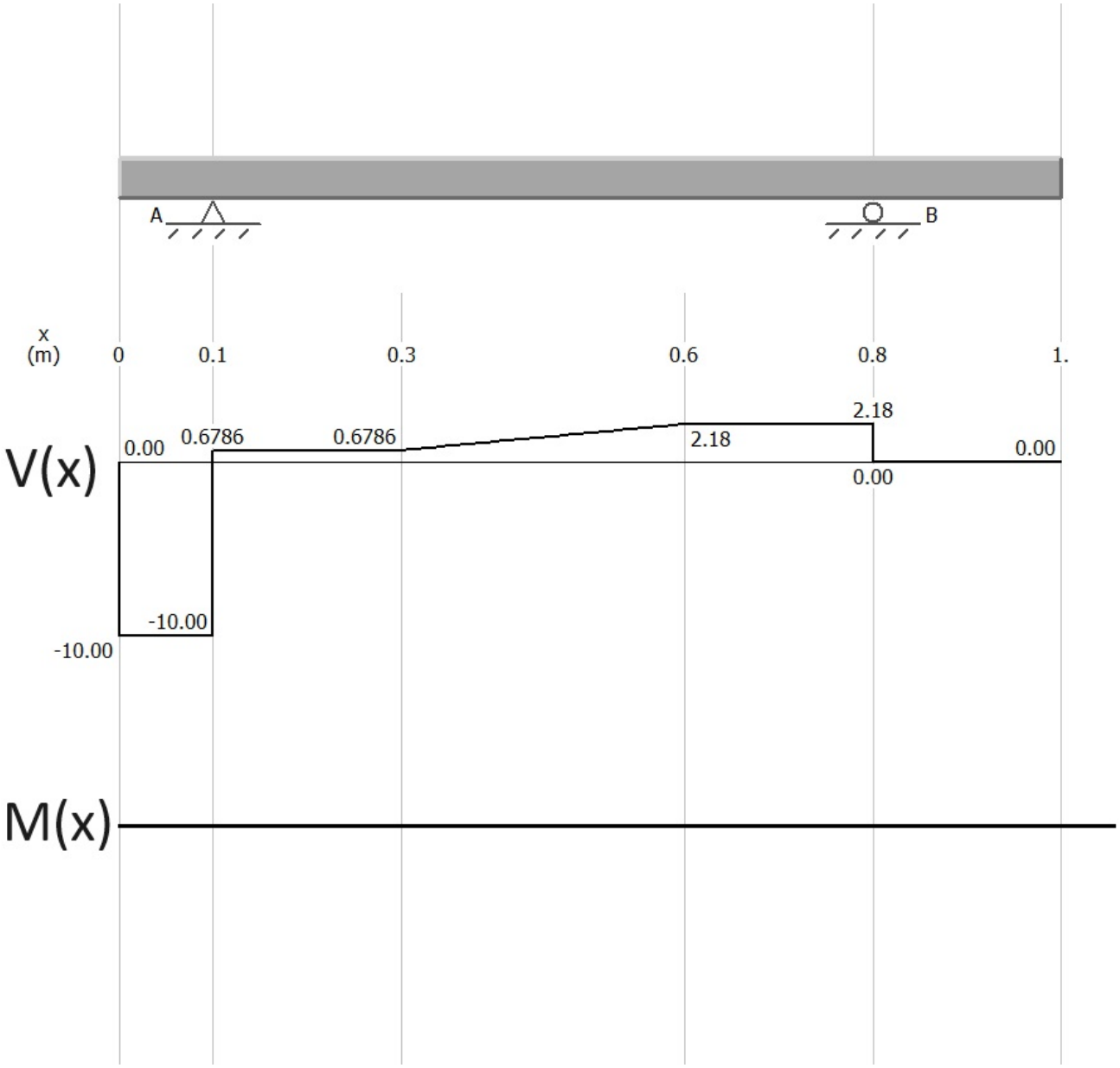
**Question 3: (30%)**
For the cross-sectional area of a beam shown below,
**a.** Determine the center of area $C$.
**b.** Determine the tensor of moments of inertia for area in $x' - y'$ coordinate system.
**c.** By using Mohr's circle, find the maximum and minimum values of the moments, and draw the rotated form of $x' - y'$ coordinate system in which these max and min values happen.
**Solution 3:**



**Question 4: (20%)**
The ends of the uniform bar of mass $m$ slide freely in the horizontal and vertical guides. The spring of stiffness $k$ is undeformed when $x = 0$.
**a.** By using the virtual work method find two conditions of equilibrium for the system.
**b.** Investigate the stability of these equilibrium conditions.
**Solution 4:**



**Question 5: (15%)**
For the uniform slender beam simply supported at $A$ and $B$, shear force diagram is depicted below. Values for force are in N and for distance are in m.
**a.** Draw the external loading on the beam.
**b.** Draw the internal moment diagram accordingly.
**Solution 5:**



# Gebze Technical University

Department of Mechanical Engineering

## ME 231 - Statics

Fall 2022, Mid-term exam #1
07 November 2022

**Time Allowed:** 120 minutes

**Attention!**

- Please read carefully before you start answering the questions.
- Books or notes are not allowed. You can use calculators.
- You are not allowed to leave the exam for any reason, before handing in the exam sheet.
- Show all the details of your answer. You will be penalized for unsystematic or unclear solutions.

| Full name | Student No. | Q1 | Q2 | Q3 | Q4 | Total |
|---|---|---|---|---|---|---|
| | | | | | | |

*Good luck, Saeed Lotfan*

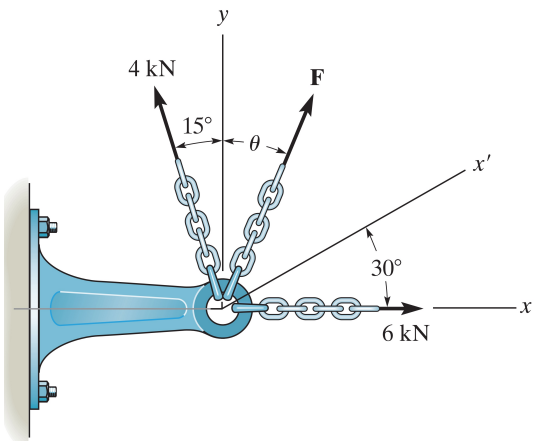
**Question 1: (20%)**

Three forces act on the bracket as shown below.

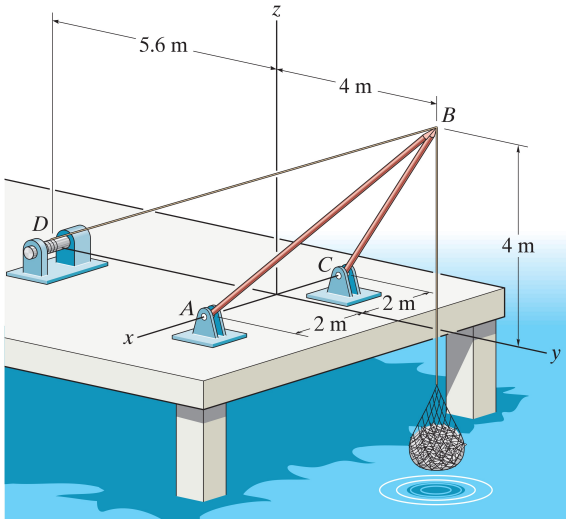
**a.** Determine the magnitude and direction $\theta$ of $F$ so that the resultant force is directed along the positive $x'$ axis and has a magnitude of 8 kN.

**b.** Resolve the 6 kN force into components along $x'$ and $y$. (Draw the corresponding parallelogram).

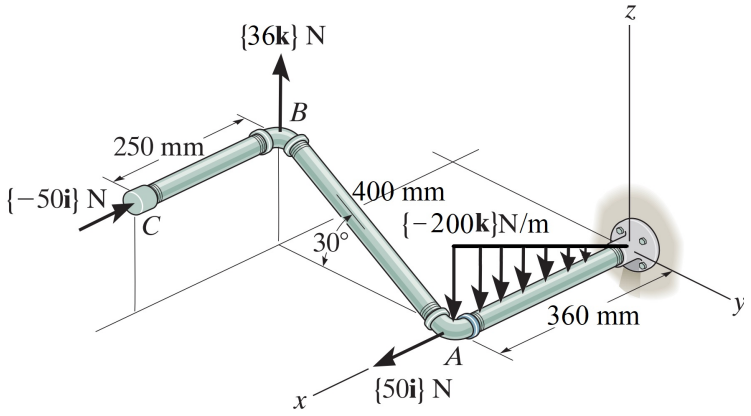
**Solution 1:**



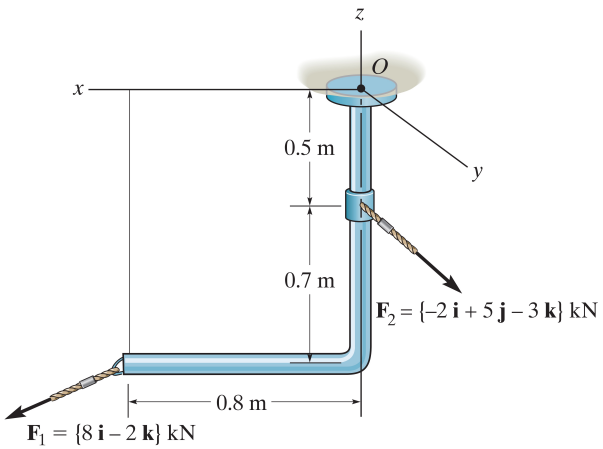
**Question 2: (30%)**
For the shear leg derrick which is used to haul the 200-kg net of fish onto the dock,
**a.** Draw free body diagrams for the 200-kg net of fish, and the cable connecting fish net to point B.
**b.** Determine the forces along each of the legs AB and CB and in the cable DB.
**c.** Displaying the free body diagram of point B, show whether the cable DB and legs are in tension or compression.
Assume the force in each leg acts along its axis and $g = 9.81$ m/s$^2$.
**Solution 2:**



**Question 3: (25%)**
For the pipe assembly shown below,
**a.** Express the resultant free moment of the exerted forces in the Caresian vector form.
**b.** Calculate the moment that is produced along the pipe AB.
**Solution 3:**



**Question 4: (25%)**
For the L-shape bar below,
**a.** Replace the loading by an equivalent resultant force and couple moment at point O.
**b.** Determine the angle $\theta$ between the resultant force and couple moment in part **a**.
**c.** Reduce the loading to a wrench and determine the position of it with respect to point O.
**Solution 4:**



# Gebze Technical University

Department of Mechanical Engineering

## ME 231 - Statics

Fall 2022, Mid-term exam #2

12 December 2022

**Time Allowed:** 150 minutes

**Attention!**

- Please read carefully before you start answering the questions.
- Books or notes are not allowed. You can use calculators.
- You are not allowed to leave the exam for any reason, before handing in the exam sheet.
- Show all the details of your answer. You will be penalized for unsystematic or unclear solutions.

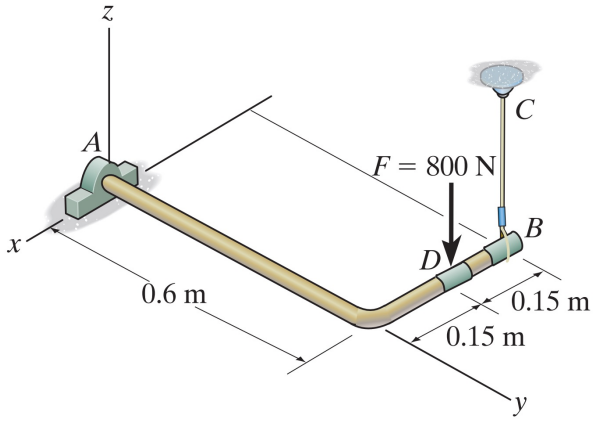
| Full name | Student No. | Q1 | Q2 | Q3 | Q4 | Total |
|---|---|---|---|---|---|---|
| | | | | | | |

*Good luck, Saeed Lotfan*

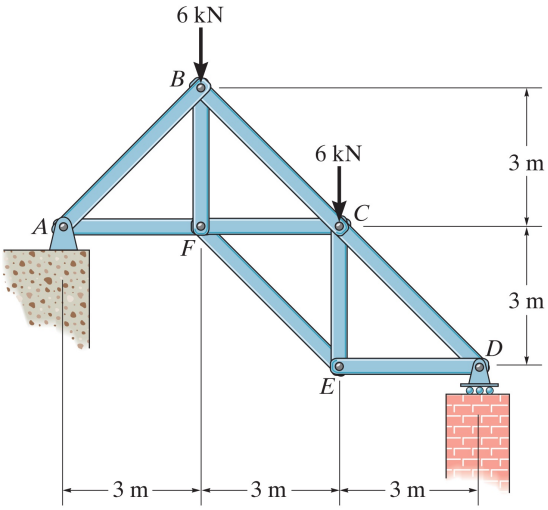
**Question 1: (17%)**

Determine the components of the reaction that the thrust bearing A and cable BC exert on the bar. (You must draw the necessary free-body diagram(s) for your solution.)

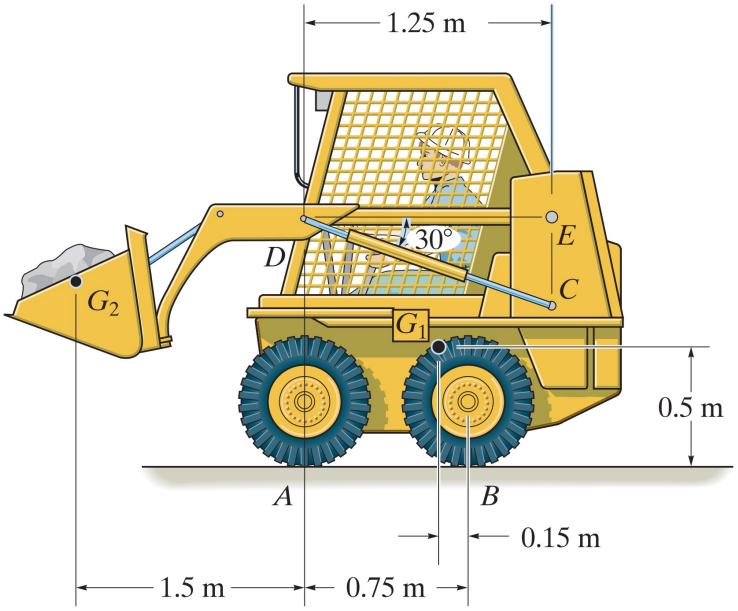
**Solution 1:**



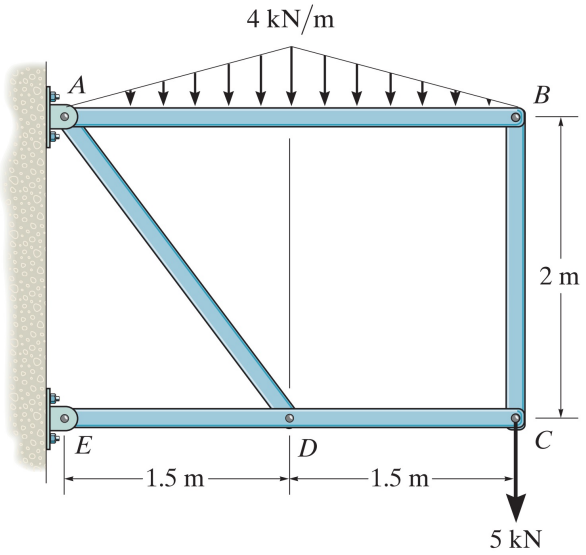
**Question 2: (29%)**
Determine the force in members BC, FC, and FE and state if the members are in tension or compression. (You must draw the necessary free-body diagram(s) for your solution.)
**Solution 2:**



**Question 3: (20%)**
The skid-steer loader has a mass of 1.18 Mg and in the position shown the center of mass is at $G_1$. If there is a 300-kg stone in the bucket, with the center of mass at $G_2$, determine the reactions of each pair of wheels A and B on the ground and the force in the hydraulic cylinder CD and at the pin E. There is a similar linkage on each side of the loader. (You must draw the necessary free-body diagram(s) for your solution.)
**Solution 3:**



**Question 4: (34%)**
For the structure below,
**a.** Determine the components of reaction forces are all connections.
**b.** Obtain the shear force and bending moment functions and show them in diagrams for the beam AB. (You must draw the necessary free-body diagram(s) for your solution.)
**Solution 4:**



# Gebze Technical University

Department of Mechanical Engineering

## ME/AERO 231 - Statics

Fall 2022, Final exam
09 January 2023

**Time Allowed:** 120 minutes

**Attention!**

- Please read carefully before you start answering the questions.
- Books or notes are not allowed. You can use calculators.
- You are not allowed to leave the exam for any reason, before handing in the exam sheet.
- Show all the details of your answer. You will be penalized for unsystematic or unclear solutions.

| Full name | Student No. | Q1 | Q2 | Q3 | Total |
|---|---|---|---|---|---|
| | | | | | |

*Good luck, Saeed Lotfan*

**Question 1: (30%)**

The semi-cylindrical shell of mass 0.1 kg and radius r is rolled through an angle by the force P which remains tangent to its periphery at A as shown.

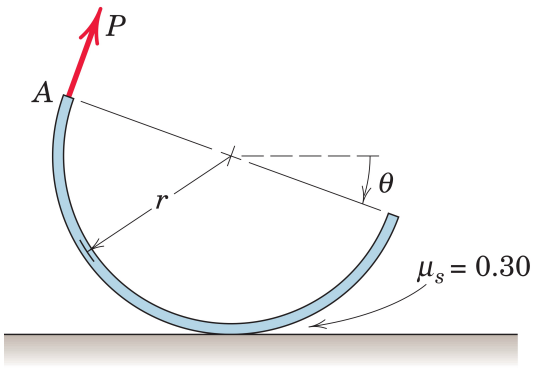
**a.** If P is slowly increased, plot the tilt angle as a function of P for $0° \leq \theta \leq 40°$.

**b.** If the tilt angle increases to 45°, does slipping occur?

The coefficient of static friction is 0.30, and $g = 10m/s^2$.

(You must draw the necessary free-body diagram(s) for your solution.)

**Solution 1:**



**Question 2: (35%)**

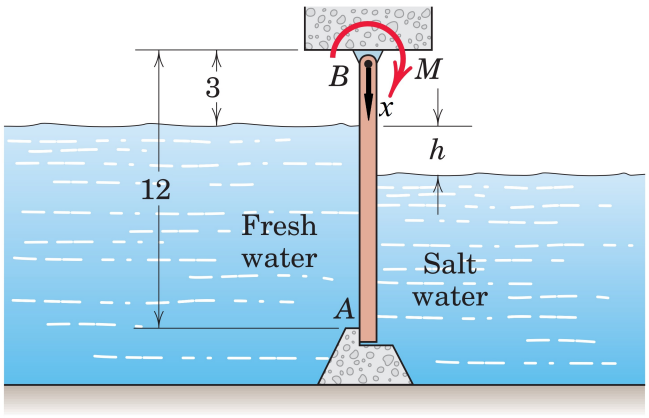
The rectangular gate shown in section is 10 m long (perpendicular to the paper) and is hinged about its upper edge B. The gate divides a channel leading to a fresh-water lake on the left with $\rho_{fw} = 1000$ kg/m$^3$ and a saltwater tidal basin on the right with $\rho_{sw} = 1025$ kg/m$^3$.

**a.** Calculate the torque M on the shaft of the gate at B required to prevent the gate from opening when the salt-water level drops to $h = 3$ m.

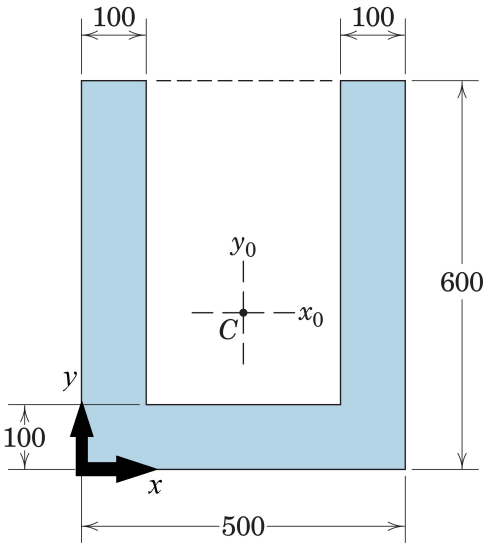
**b.** Plot the shear $V(x)$ and bending moment $M(x)$ along the gate.

(You must draw the necessary free-body diagram(s) for your solution and assume $g = 9.81$m/s$^2$.)

**Solution 2:**



**Question 3: (35%)**
The cross-sectional area of a cantilever beam of length 1 m and density 7850 kg/m$^3$ is shown below.
**a.** Determine the centroid of the cross-section defined in $x-y$ coordinates.
**b.** Determine the tensor of the moments of inertia for area in the $x-y$ coordinates.
**c.** Obtain the diagonal form of the matrix in **b** by using Mohr's circle method.
**d.** Determine the mass moment of inertia about the axis along the length of the beam and passing through point C.
**Solution 3:**



**For solutions:**