Statics

Problem Set 01

1.1 Resolve \( \mathbf{F}_1 \) and \( \mathbf{F}_2 \) into components along the \( u \) and \( v \) axes, and determine the magnitudes of these components.

1.2 If \( \theta = 30^\circ \) and \( F_2 = 6 \) kN, determine the magnitude of the resultant force acting on the plate and its direction measured clockwise from the positive \( x \) axis.

1.3 If the magnitude of the resultant force acting on the eyebolt is 600 N and its direction measured clockwise from the positive \( x \) axis is \( \theta = 30^\circ \), determine the magnitude of \( \mathbf{F}_1 \) and the angle \( \beta \).

1.4 The cylindrical plate is subjected to the three cable forces which are concurrent at point \( D \). Express each force which the cables exert on the plate as a Cartesian vector, and determine the magnitude and coordinate direction angles of the resultant force.

1.5 Determine the tension developed in wires \( \mathbf{AC} \) and \( \mathbf{BC} \) required for equilibrium of the 10-kg cylinder. Take \( \theta = 40^\circ \).

1.6 Determine the tensions developed in wires \( \mathbf{AB} \), \( \mathbf{BC} \) and \( \mathbf{CD} \) and the angle \( \theta \) required for equilibrium of the 30-lb cylinder \( \mathbf{E} \) and the 60-lb cylinder \( \mathbf{F} \).

1.7 A scale is constructed using the 10-kg mass, the 2-kg pan \( \mathbf{P} \), and the pulley and cord arrangement. Cord \( \mathbf{BCA} \) is 2 m long. If \( s = 0.75 \) m, determine the mass \( \mathbf{D} \) in the pan. Neglect the size of the pulley.

1.8 The ends of the three cables are attached to a ring at \( \mathbf{A} \) and to the edge of a uniform 150-kg plate. Determine the tension in each of the cables for equilibrium.
Statics

2.1 The rod on the power control mechanism for a business jet is subjected to a force of 80 N. Determine the moment of this force about the bearing at $A$.

2.2 A 20-N horizontal force is applied perpendicular to the handle of the socket wrench. Determine the magnitude and the coordinate direction angles of the moment created by this force about point $O$.

2.3 A vertical force of $F = 60$ N is applied to the handle of the pipe wrench. Determine the moment that this force exerts along the axis $AB$ (x axis) of the pipe assembly. Both the wrench and pipe assembly $ABC$ lie in the plane. Suggestion: Use a scalar analysis.

2.4 Determine the moment produced by force $F$ about the diagonal $OD$ of the rectangular block. Express the result as a Cartesian vector.

2.5 Replace the force and couple moment system acting on the overhang beam by a resultant force, and specify its location along $AB$ measured from point $A$.

2.6 Replace the force system acting on the truss by a resultant force and couple moment at point $C$.

2.7 Handle forces $F_1$ and $F_2$ are applied to the electric drill. Replace this force system by an equivalent resultant force and couple moment acting at point $O$. Express the results in Cartesian vector form.

\[ F_1 = [6i - 3j - 10k] \text{ N} \]

\[ F_2 = [-6i + 3j + 10k] \text{ N} \]
Statics

Problem Set 03

3.1 Determine the horizontal and vertical components of reaction at A and the normal reaction at B on the spanner wrench.

3.2 As an airplane's brakes are applied, the nose wheel exerts two forces on the end of the landing gear as shown. Determine the horizontal and vertical components of reaction at the pin C and the force in strut AB.

3.3 The train car has a weight of 24,000 lb and a center of gravity at G. It is suspended from its front and rear on the track by six tires located at A, B, and C. Determine the normal reactions on these tires if the track is assumed to be a smooth surface and an equal portion of the load is supported at both the front and rear tires.

3.4 If the force of \( F = 100 \) lb is applied to the handle of the bar bender, determine the horizontal and vertical components of reaction at pin A and the reaction of the roller B on the smooth bar.

3.5 Determine the angle \( \theta \) at which the link ABC is held in equilibrium if member BD moves 2 in. to the right. The springs are originally unstretched when \( \theta = 0^\circ \). The springs remain horizontal by means of roller guides.

3.6 A vertical force of 80 lb acts on the crankshaft. Determine the horizontal equilibrium force \( P \) that must be applied to the handle and the \( x, y, z \) components of force at the smooth journal bearing A and the thrust bearing B. The bearings are properly aligned and exert only force reactions on the shaft.
4.1 Determine the force in each member of the truss, and state if the members are in tension or compression. Set $P = 800$ lb.

4.2 Determine the force in members $IC$ and $CG$ of the truss and state if these members are in tension or compression.

4.3 Determine the force in members $BC$ and $CH$ of the truss and state if these members are in tension or compression.

4.4 Determine the force that the smooth roller $C$ exerts on member $AB$. Also, what are the horizontal and vertical components of reaction at pin $A$?

4.5 Determine the horizontal and vertical components of reaction at the pins $A$ and $D$. Also, what is the force in the cable at the winch $W$?

4.6 The tractor shovel carries a 500-kg load of soil, having a center of mass at $G$. Compute the forces developed in the hydraulic cylinders $IJ$ and $BC$ due to this loading.

4.7 Find the clamping force exerted on the smooth pipe $A$ if a force of 5 lb is applied to the handles of the pliers.
Statics

Problem Set 05

5.1 Determine the mass and the location of the center of mass of the rod if its mass per unit length is
\[ m = m_0(1 + x/L). \]

5.2 The steel plate is 0.3 m thick and has a density of 7850 kg/m³. Determine the location of its center of mass. Also determine the horizontal and vertical reactions at the pin and the reaction at the roller support. Hint: The normal force at \( B \) is perpendicular to the tangent at \( B \), which is found from \( \tan \theta \frac{dy}{dx} \).

5.3 Determine the volume and locate the centroid \( \bar{y}, \bar{z} \) of the homogeneous conical wedge.

5.4 Locate the centroid \( (\bar{x}, \bar{y}, \bar{z}) \) of the wire which is bent in the shape shown.

5.5 Locate the centroid \( \bar{y} \) of the beam’s cross-sectional area.

5.6 Locate the center of gravity \( (\bar{x}, \bar{z}) \) of the sheetmetal bracket if the material is homogeneous and has a constant thickness. If the bracket is resting on the horizontal \( x-y \) plane shown, determine the maximum angle of tilt \( \theta \) which it can have before it falls over, i.e., begins to rotate about the \( y \) axis.

5.7 The water tank \( AB \) has a hemispherical top and is fabricated from thin steel plate. Determine the surface area of the tank shell and volume within the tank using Pappus and Guldinus theorem.

5.8 Determine the centroid of the casted bracket from the bottom of base.
Statics

Problem Set 06

6.1 Determine the internal normal force, shear force, and moment at point C.

6.2 Determine the internal normal force, shear force, and moment at points D and E of the frame which supports the 200-lb crate. Neglect the size of the smooth peg at C.

6.3 Determine the ratio of \( a/b \) for which the shear force will be zero at the midpoint C of the double-overhang beam.

6.4 The stacker crane supports a 1.5-Mg boat with the center of mass at G. Determine the internal normal force, shear force, and moment at point D in the girder. The trolley is free to roll along the girder rail and is located at the position shown. Only vertical reactions occur at A and B.

6.5 Draw the shear and moment diagrams for the beams.

6.6 Determine the internal shear and moment in member ABC as a function of \( x \), where the origin for \( x \) is at A.

6.7 Draw the shear and moment diagrams for the compound beam.

6.8 Determine the internal normal force, shear force, and moment acting at points B and C on the curved rod.
Statics

Problem Set 07

7.1 The tongs are used to lift the 150-kg crate, whose center of mass is at \( G \). Determine the least coefficient of static friction at the pivot blocks so that the crate can be lifted.

7.2 The wedge blocks are used to hold the specimen in a tension testing machine. Determine the largest design angle \( \theta \) of the wedges so that the specimen will not slip regardless of the applied load. The coefficients of static friction are \( \mu_A = 0.1 \) at \( A \) and \( \mu_B = 0.6 \) at \( B \). Neglect the weight of the blocks.

7.3 If the jack is required to lift the 200-kg crate, determine the horizontal force that must be applied perpendicular to the handle at \( E \). Each single square-threaded screw has a mean diameter of 25 mm and a lead of 7.5 mm. The coefficient of static friction is \( \mu_s = 0.25 \).

7.4 The machine part is held in place using the double-end clamp. The bolt at \( B \) has square threads with a mean radius of 4 mm and a lead of 2 mm, and the coefficient of static friction with the nut is \( \mu_s = 0.2 \). If a torque of \( M = 0.4 \) N\( \cdot \)m is applied to the nut to tighten it, determine the normal force of the clamp at the smooth contacts \( A \) and \( C \).

7.5 The simple band brake is constructed so that the ends of the friction strap are connected to the pin at \( A \) and the lever arm at \( B \). If the wheel is subjected to a torque of \( M = 80 \) lb\( \cdot \)ft, determine the smallest force \( P \) applied to the lever that is required to hold the wheel stationary. The coefficient of static friction between the strap and wheel is \( \mu_s = 0.5 \).

7.6 The truck has a mass of 1.25 Mg and a center of mass at \( G \). Determine the greatest load it can pull if (a) the truck has rear-wheel drive while the front wheels are free to roll, and (b) the truck has four-wheel drive. The coefficient of static friction between the wheels and the ground is \( \mu_s = 0.5 \), and between the crate and the ground, it is \( \mu_s = 0.4 \).

7.7 The pulley is supported by a 25-mm-diameter pin. If the pulley fits loosely on the pin, determine the smallest force \( P \) required to raise the bucket. The bucket has a mass of 20 kg and the coefficient of static friction between the pulley and the pin is \( \mu_s = 0.5 \). Neglect the mass of the pulley and assume that the cable does not slip on the pulley.

7.8 Determine the force \( P \) required to overcome rolling resistance and support the 50-kg roller if it rolls down the inclined plane with constant velocity. The coefficient of rolling resistance is \( a = 15 \) mm.
8.1. Determine the moment of inertia and the radius of gyration of the area about the $y$-axis.

8.2. Determine the moment of inertia of the beam’s cross-sectional area about the $x$-axis.

8.3. Determine the moment of inertia of the shaded area about the $x$-axis.

8.4. Determine the product of inertia for the beam’s cross-sectional area with respect to the $x$ and $y$ axes that have their origin located at the centroid $C$.

8.5. Determine $I_x$, $I_y$ and $I_{xy}$ for rectangular plate with three equal circular holes.

8.6. Determine the moments and product of inertia for shaded area with respect to $x'$ and $y'$ axes.

8.7. Determine the orientation of the principal axes, which have their origin at centroid $C$ of the beam’s cross sectional area. Also, find the principal moments of inertia.
Statics

Problem Set 09

9.1. A vertical force of $P = 50$ N is applied to the handle of the toggle clamp, determine the clamping force exerted on the pipe.

9.2. Determine the magnitude of the couple moment $M$ required to support the 20-kg cylinder in the configuration shown. The smooth peg at $B$ can slide freely within the slot. Neglect the mass of the members.

9.3. The uniform links $AB$ and $BC$ each weigh 2 lb and the cylinder weighs 20 lb. Determine the horizontal force $P$ required to hold the mechanism at $\theta = 45^\circ$. The spring has an unstretched length of 6 in.

9.4. The uniform rod $OA$ weighs 20 lb, and when the rod is in the vertical position, the spring is unstretched. Determine the position $\theta$ for equilibrium. Investigate the stability at the equilibrium position.

9.5. The 2-lb semicylinder supports the block which has a specific weight of $\gamma = 90$ lb/ft$^3$. Determine the height $h$ of the block which will produce neutral equilibrium in the position shown.