Statics
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## Other Disciplines FE Specifications

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We are grateful to NCEES for granting us permission to copy short sections from the FE Handbook to show students how to use Handbook information in solving problems. This information will normally appear in these videos as white boxes.
1. Which of the following statements is not one of Newton’s Laws of Motion?

   A) The acceleration of a body is proportional to any unbalanced force acting on the body.

   B) The forces between two bodies in contact are equal, opposite, and have the same line of action.

   C) The force acting on a rope must always be such that the rope is in tension and cannot vary along the rope.

   D) A body remains at rest, or in a straight line at constant velocity, unless acted upon by an unbalanced force.
1. Which of the following statements is not one of Newton’s Laws of Motion?

A) The acceleration of a body is proportional to any unbalanced force acting on the body.

   Newton’s 2\textsuperscript{nd} law (F=ma)

B) The forces between two bodies in contact are equal, opposite, and have the same line of action.

   Newton’s 3\textsuperscript{rd} law

C) The force acting on a rope must always be such that the rope is in tension and cannot vary along the rope.

   True, but not one of Newton’s laws

D) A body remains at rest, or in a straight line at constant velocity, unless acted upon by an unbalanced force.

   Newton’s 1\textsuperscript{st} law
2. At what angle \( (\theta) \) should the 60 N force act for the resultant \( (R) \) of the three forces shown to be along the x-axis?

\[ \text{A) } 40^\circ \quad \text{B) } 50^\circ \quad \text{C) } 60^\circ \quad \text{D) } 70^\circ \]
Solution – Problem 2 (Page 72- Ref. Handbook)
Since the resultant $R$ is along the $x$ axis it has no vertical component. Hence the sum of the vertical components of the three forces that make up $R$ must be zero, ie.

$$\sum F_v = 0$$

$$40 \cos 30^\circ + 50 \sin 20^\circ - 60 \sin \theta = 0$$

$$\sin \theta = \frac{(40)(.866) + (50)(.342)}{60} = 0.862$$

$$\theta = 59.8^\circ \approx 60^\circ$$

C)
3. What is the moment of the 300 N force acting at point C of the beam shown about the pin support at point A?

A) 305 N·m  B) 825 N·m  C) 1130 N·m  D) 1950 N·m
Solution – Problem 3  (Page 72- Ref. Handbook)

It is easiest to first resolve 300 N force at C into vertical and horizontal components.

\[ 300 \cos 20^\circ = 282 \, \text{N} \]
\[ 300 \sin 20^\circ = 103 \, \text{N} \]

Now calculate moment from both components about point A. (clockwise +)

\[ M_A = (103 \, \text{N})(8 \, \text{m}) - (282 \, \text{N})(4 \, \text{m}) \]
\[ = 824 \, \text{Nm} - 1128 \, \text{Nm} = -304 \, \text{Nm} \]  
A)
4. Determine the force (F) needed to hold the 500 N cylinder shown in equilibrium on the frictionless inclined surface.

A) 375 N  B) 500 N  C) 625 N  D) 835 N
Solution – Problem 4

Start with free body diagram of cylinder and break up surface reaction R into horizontal and vertical components.

Apply equations of equilibrium

\[ \sum F_H = 0 \quad F = \frac{3}{5} R \]

\[ \sum F_V = 0 \quad 500 \text{ N} = \frac{4}{5} R \quad \Rightarrow \quad R = \frac{2500}{4} \text{ N} \]

then \[ F = \frac{3}{5} R = \frac{1500}{4} \text{ N} = 375 \text{ N} \] A)
5. Determine the reaction at the roller support at point A for the loading on the beam shown.

A) 120 N  B) 255 N  C) 330 N  D) 445 N
Solution – Problem 5

First, determine resultants of distributed loads; area under distribution acting through centroid.

Apply moment equilibrium about point B to eliminate \( R_B \) from consideration.

\[
\sum M_B = 0
\]

\[
R_A \times 20 - 150 \times 18 - 100 \times 11 + 2000 - 300 \times 2 = 0
\]

\[
R_A = \frac{2700 + 1100 - 2000 + 600}{20} = 120\text{N}
\]
6. What value of the force (P) in terms of the weight (W) is necessary for the pulley system shown to be in equilibrium?

A) W  B) W ÷ 2  C) W ÷ 4  D) W ÷ 8
Solution – Problem 6

Draw free body diagram with all external forces on each pulley sequentially starting at the right recognizing that tension in cable over pulley is constant since there is no friction.

Check equilibrium of three attachments to fixed surface.

\[ \frac{W}{2} + \frac{W}{4} + \frac{W}{2} = W + P \]

\( P = \frac{W}{4} \)
7. Identify, if any, the zero force members of the truss shown. There are downward loads (P) acting only at joints F and H.

A) CH  B) CH, DG  C) CH, DG, DH  D) None
Rule 1 -
If only two members form a truss joint and no external load or support reaction is applied at the joint, the members are zero force members.

Rule 2 –
If three members form a truss joint for which two of the members are collinear the third member is a zero force strut provided no external force or support reaction is applied to the joint.
1. CH is a zero force member by Rule 2
2. DG is a zero force member by Rule 2
3. HD is a zero force member by Rule 2

\( \Rightarrow \)
8. Determine the force in member EF of the truss shown.

A) 5 kN  
B) 10 kN  
C) 21 kN  
D) 25 kN
Solution – Problem 8

Use method of sections with free body diagram on left. Apply equilibrium equations to solve for 3 unknown forces.

\[ \sum M_E = 0 \quad 5 \text{ kn}(4) - F_{CB}(4) = 0 \quad \Rightarrow \quad F_{CB} = 5 \text{ kn} \]

\[ \sum F_{\text{hort}} = 0 \quad 10 \text{ kn} + 5 \text{ kn} - F_{EB}\cos 45^\circ = 0 \]

\[ F_{EB} = \frac{15 \text{ kn}}{0.707} = 21.2 \text{ kn} \]

\[ \sum F_{\text{vert}} = 0 \quad F_{EF} + 5\text{ kn} + 5\text{ kn} + 21.2(0.707) = 0 \quad F_{EF} = -25 \text{ kn} \]
9. Locate the centroid of the composite area shown relative to the given xy coordinate system.

A) $\bar{x} = 1.2 \text{ cm}, \bar{y} = 4.5 \text{ cm}$

B) $\bar{x} = 1.9 \text{ cm}, \bar{y} = 5.4 \text{ cm}$

C) $\bar{x} = 2.4 \text{ cm}, \bar{y} = 5.0 \text{ cm}$

D) $\bar{x} = 3.0 \text{ cm}, \bar{y} = 4.5 \text{ cm}$
Solution – Problem 9

Use definition of centroid

\[ \bar{x} = \frac{\sum A_i x_i}{\sum A_i} \quad \bar{y} = \frac{\sum A_i y_i}{\sum A_i} \]

<table>
<thead>
<tr>
<th>Section</th>
<th>( A_i ) (cm(^2))</th>
<th>( x_i ) (cm)</th>
<th>( y_i ) (cm)</th>
<th>( A_i x_i ) (cm(^3))</th>
<th>( A_i y_i ) (cm(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>triangle</td>
<td>36</td>
<td>-2</td>
<td>6</td>
<td>-72</td>
<td>144</td>
</tr>
<tr>
<td>rectangle</td>
<td>108</td>
<td>4.5</td>
<td>6</td>
<td>486</td>
<td>648</td>
</tr>
<tr>
<td>semi-circle</td>
<td>-25.1</td>
<td>7.3</td>
<td>6</td>
<td>-183.5</td>
<td>-150.8</td>
</tr>
<tr>
<td>Summation</td>
<td>118.9</td>
<td></td>
<td></td>
<td>230.5</td>
<td>641.2</td>
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\[ \bar{x} = \frac{230.5}{118.9} = 1.94 \text{ cm}, \quad \bar{y} = \frac{641.2}{118.9} = 5.39 \text{ cm} \]

B)
10. Determine the moment of inertia of the Tee section shown about its horizontal centroidal axis, which has been located.

A) 173 cm\(^4\)  B) 343 cm\(^4\)  C) 533 cm\(^4\)  D) 753 cm\(^4\)
Solution – Problem 10

Use parallel axis theorem

\[ I_C = (I_t + A_t d_t^2) + (I_b + A_b d_b^2) \]

\[ I_{\text{rect}} = \frac{bh^3}{12} \]

\[ I_t = \frac{(10)(2)^3}{12} = 6.67 \text{ cm}^4, \quad A_t = (10)(2) = 20 \text{ cm}^2, \quad d_t = 2 + 1 = 3 \text{ cm} \]

\[ I_b = \frac{(2)(10^3)}{12} = 166.7 \text{ cm}^4, \quad A_b = (2)(10) = 20 \text{ cm}^2, \quad d_b = 8 - 5 = 3 \text{ cm} \]

\[ I_C = (6.67 + 20 \times 3^2) + (166.7 + 20 \times 3^2) = 533.3 \text{ cm}^4 \]
11. What is the relationship between the maximum angle ($\theta$) for impending slipping of the block on the incline and the coefficient of static friction ($\mu_s$).

\begin{align*}
A) \quad \sin \theta_{\text{max}} &= \mu_s \\
B) \quad \cos \theta_{\text{max}} &= \mu_s \\
C) \quad \tan \theta_{\text{max}} &= \mu_s \\
D) \quad \sec \theta_{\text{max}} &= \mu_s
\end{align*}
Solution – Problem 11

Slippage will begin to take place when component of $W$ along plane is equal to $\mu_s N$.

Apply equilibrium to all forces on free body diagram of block.

\[ \sum F_y = 0 \quad N - W \cos \theta = 0 \quad \Rightarrow \quad N = W \cos \theta \]

\[ \sum F_x = 0 \quad \mu_s N - W \sin \theta = 0 \quad \text{or} \]

\[ \mu_s W \cos \theta = W \sin \theta \quad \Rightarrow \quad \mu_s = \frac{\sin \theta}{\cos \theta} = \tan \theta \]

C
12. Determine an algebraic expression that relates the width (x) of the triangular block to its height (h) and the coefficient of static friction ($\mu_s$) for the block to as likely slip as it is to tip.

A) $x = \mu_s h$

B) $x = 2 \mu_s h$

C) $x = 3 \mu_s h$

D) $x = 4 \mu_s h$
At instant of tipping forces on block will be as shown on left. Satisfy equations of equilibrium for assumed force system.

\[ \sum F_{\text{horizontal}} = 0 \quad P = \mu_s N \]

\[ \sum F_{\text{vertical}} = 0 \quad W = N \]

\[ \sum M_o = 0 \quad P \left( h \right) = W \left( \frac{x}{2} \right) \quad \text{or} \]

\[ \mu_s W \left( h \right) = W \left( \frac{x}{2} \right) \quad \Rightarrow \quad x = 2 \mu_s h \]

B)