EGR 140
Statics

Test #2 Overview

Chapters covered: 4-5 in Statics, 13th Edition, by Hibbeler
Breakdown: Chapter 4 material: ≈ 50 %
Chapter 5 material: ≈ 50 %
Related Homework Assignments: Chapter 4-5 Homework Assignments
Format: No books, notes, or formula sheets are allowed on the test.
Copies of Tables 5-1 (2D reactions) and 5-2 (3D reactions) from the text will be provided.
Problems are similar to homework, class, and textbook problems mainly.
Probably 5-8 problems.
Occasional multiple choice, True/False, etc. (probably 15% or less of the test)
Hints for success: Work more textbook problems for preparation.
Study the sample problems in the textbook.
Include Free Body Diagrams (FBDs) in your solution.
Show clear diagrams and all work on the test.
If significant work is done using a calculator, write down what you entered into the calculator for possible partial credit.

Chapter 4 – Force System Resultants (Moments) - Major Topics

Moment = torque = twisting action (about a point)
A moment is a vector quantity.
In 2D it is expressed by a magnitude and a direction: CW(-) or CCW(+)
Note: the direction is determined by inspection
In 3D it is expressed using rectangular components

Determining moments in 2D - 4 methods:

1) $M = (F_\perp)D$ {the perpendicular component of the force multiplied by the distance}
2) $M = F(D_\perp)$ {the force multiplied by the perpendicular component of the distance}
3) Using rectangular components for both F and D
4) Using a cross product

Determining moments in 3D - Use a cross product: $\overline{M}_A = \bar{r} \times \bar{F} = M_x\mathbf{i} + M_y\mathbf{j} + M_z\mathbf{k}$

Note the $\bar{r}$ is the position vector from point A to any point along the line of action of F.

Moment of a force about a line

M_x = moment about the x-axis, M_y = moment about the y-axis, M_z = moment about the z-axis
M_{AB} = moment about the line AB
$|M_{AB}| = \bar{u}_{AB} \bullet \overline{M}_A = \bar{u}_{AB} \bullet [\bar{r} \times \bar{F}]$

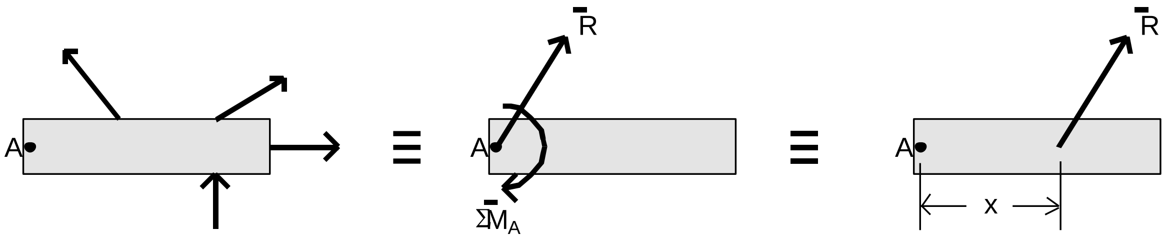
Couples - A couple is a moment resulting from two forces that are equal in magnitude, opposite in direction, and have different lines of action. A couple is a free vector and is independent of any point, so it may be placed anywhere on an object.

Equivalent Systems - A given system of forces and moments may be represented in two alternate ways:

1) As a resultant force and a couple at some point A, where

$R = \sum F$ (for the original system) and $M_A = \sum M_A$ (for the original system)

2) As a single resultant force strategically placed to produce the same M_A as in the original system.



Original system of forces
Find $\bar{R} = \Sigma\bar{F}$ and $\Sigma\bar{M}_A$

Resultant force + moment

Resultant force + moment
$\bar{R}$ strategically placed a distance x from point A in order to yield the same $\Sigma\bar{M}_A$

Chapter 5 (Equilibrium of Rigid Bodies) - Major Topics

Free Body Diagram (FBD) - One of the most important concepts in this course
Include a FBD with every solution.
Steps to forming a FBD:

1) Identify the object to be isolated
2) Sketch the object to be isolated with appropriate angles
3) Draw vectors representing all external forces acting on the isolated object (including gravitational forces)

2D Equilibrium:
FBD is essential. Refer to Table 5-1 for reactions at 2D supports (provided on tests).

2D Equilibrium equations: (3 equations total in most cases)

- most common set of equations: $\Sigma F_x = 0$, $\Sigma F_y = 0$, $\Sigma M_A = 0$ (for any point A)
- other possible sets: 1) $\Sigma F_x = 0$, $\Sigma M_A = 0$, $\Sigma M_B = 0$ (A and B not on a vertical line)
  2) $\Sigma F_y = 0$, $\Sigma M_A = 0$, $\Sigma M_B = 0$ (A and B not on a horizontal line)
  3) $\Sigma M_A = 0$, $\Sigma M_B = 0$, $\Sigma M_C = 0$ (A, B, and C not on any line)

3D Equilibrium:
FBD is essential. Refer to Table 5-2 for reactions at 3D supports (provided on tests).
Use cross products in determining moments.

3D Equilibrium equations: (6 equations total in most cases)

$\sum \bar{F} = 0$ on the free body yields: $\Sigma F_x = 0$, $\Sigma F_y = 0$, $\Sigma F_z = 0$

$\sum \overline{M}_A = \sum \left(\bar{r} \times \bar{F}\right) = 0$ at any point A yields: $\Sigma M_x = 0$, $\Sigma M_y = 0$, $\Sigma M_z = 0$

Note that you can also apply $\Sigma M_x = 0$, $\Sigma M_y = 0$, $\Sigma M_z = 0$ by applying a moment about each axis (one axis at a time). This works well for fairly simple FBDs.

Two-force members: Forces act along the axis of the member (the line connecting its endpoints).
Forces at supports represented by single unknown.

Three-force members: Forces must be either concurrent or parallel.
Forces at supports represented by both x and y components.