EGR 140
Statics

# Test #2 Overview

**Chapters covered:** 3 & 4 from Statics, 8th Edition, by Beer & Johnston
**Breakdown:** Chapter 3 material: ≈50 %
Chapter 4 material: ≈50 %
**Format:** Similar to class examples, homework problems, and textbook problems
**Hints for success:** Work more problems for preparation.
Include Free Body Diagrams (FBDs) in your solution.
Show clear diagrams and all work on the test.

## Chapter 3 (Rigid Bodies – Equivalent Systems of Forces) - 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: $\overline{M}_A = \overline{r} \times \overline{F} = M_x\mathbf{i} + M_y\mathbf{j} + M_z\mathbf{k}$

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

**Dot Products:** $\vec{P} \bullet \vec{Q} = PQ\cos\theta$ (scalar result)

Applications:

1) Determining the angle between two vectors

$$\overline{A} \bullet \overline{B} = |A| \cdot |B| \cdot \cos(\theta)$$

$$\boxed{\cos(\theta) = \frac{\overline{A} \bullet \overline{B}}{|A| \cdot |B|} = \frac{A_xB_x + A_yB_y + A_zB_z}{\sqrt{A_x^2 + A_y^2 + A_z^2} \cdot \sqrt{B_x^2 + B_y^2 + B_z^2}}}$$

2) Determining the projection of a vector along a line

$$P_{OL} = P\cos\theta = \text{projection of } P \text{ along } OL$$

$$\vec{P} \bullet \vec{Q} = PQ\cos\theta$$

$$\frac{\vec{P} \bullet \vec{Q}}{Q} = P\cos\theta = P_{OL}$$

**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

$$|M_{AB}| = \overline{\lambda}_{AB} \bullet \overline{M}_A = \overline{\lambda}_{AB} \bullet \left[\overline{r} \times \overline{F}\right]$$

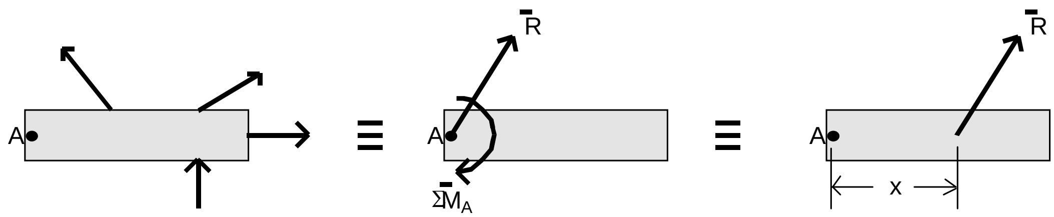
**<u>Couples</u>** - A couple is a moment resulting from two forces that are equal in magnitude, opposite in direction, and have different lines of action. A couple is a free vector and is independent of any point, so it may be placed anywhere on an object.

**<u>Equivalent Systems</u>** - 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 $\Sigma\bar{M}_A$

## <u>Chapter 4 (Equilibrium of Rigid Bodies)</u> - Major Topics

**<u>Free Body Diagram (FBD)</u>** - 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)

**<u>2D Equilibrium</u>:**
FBD is essential. Refer to Fig. 4.1 for reactions at 2D supports (provided on tests).
**<u>2D Equilibrium equations</u>:** (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)

**<u>3D Equilibrium</u>:**
FBD is essential. Refer to Fig. 4.10 for reactions at 3D supports (provided on tests).
Use cross products in determining moments.
**<u>3D Equilibrium equations</u>:** (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: $\Sigma M_x = 0$ , $\Sigma M_y = 0$ , $\Sigma M_z = 0$

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

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