Review of Week 1-7

- Week 1
  - Vector Manipulation, Addition, Subtraction, Unit Vector, Dot Product, Cross Product, Mixed Triple Product
- Week 2
  - Torque and moment, moment about a line, simplification (Wrench)
- *Week 3: Free Body diagrams*
- *Week 4: Objects & Systems in Equilibrium*
- *Week 5: Centroids and Center of Mass*
- *Week 6: Friction*
- *Week 7: Biomedical Applications*

Explicit Topics on Exam

- Week 1
  - Vector Manipulation, Addition, Subtraction, Unit Vector, Dot Product, Cross Product, Mixed Triple Product
- Week 2
  - Torque and moment, moment about a line, simplification (Wrench)
- *Week 3: Free Body diagrams*
- *Week 4: Objects & Systems in Equilibrium (2)*
- *Week 5: Centroids and Center of Mass*
- *Week 6: Friction (2)*
- *Week 7: Biomedical Applications (2)*

Exam

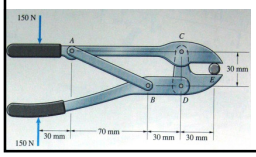
Next week (31 July):
3-hour Midterm on weeks 1-7
Assigned seats, *different* exams (so don't copy ☺)
Turn off phones, No bathroom breaks during exam
6 problems:
  Three *2D* problems
  Three *3D* problems

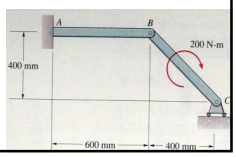
Formula Sheet

- Not required
- Must be original (Copying is not allowed)
- Must be typed, and include your name
- Must submit to Dr. Jon along with your exam
- 1 page, front and back
- See Syllabus for details

2D System Equilibrium

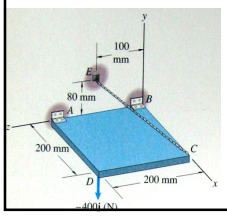
- 15 points
  - 13 points for math
    - 5 points for equal/opposite forces
  - 1 point for dimensions
  - 1 point for answer

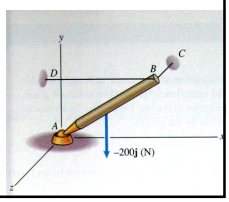




3D Equilibrium

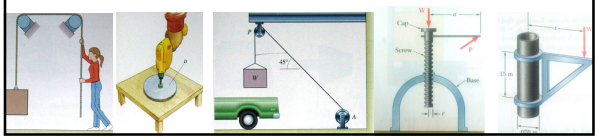
- 20 points
  - 10 points for concepts
  - 6 points for math
  - 2 points for answers
  - 2 points for dimensions





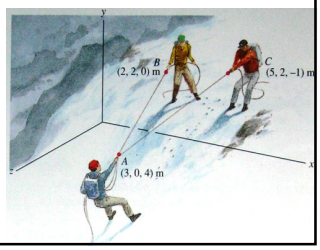
2D Friction

- 10 points



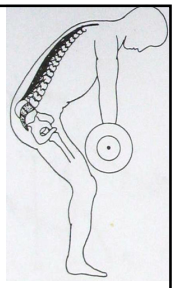
3D Friction

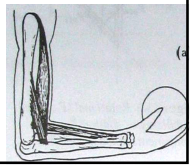
- 20 points
  - 13 for description
  - 7 for math



2D Biomedical

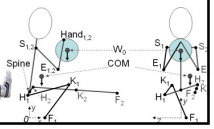
- 20 points
- Part A (5 points)
  - 3 points for math
  - 1 point for answer
  - 1 point for dimensions
- Part B (15 points)
  - 4 points for correct concept
  - 9 points for math
  - 1 point for answer
  - 1 point for dimensions



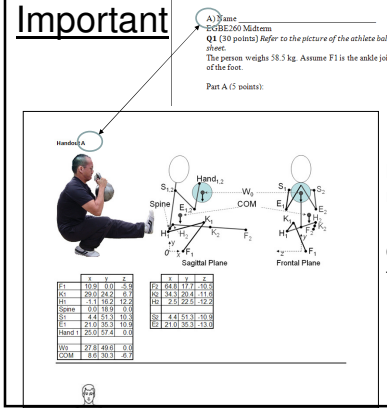


3D Biomedical

- 30 points
  - Part A (5 points)
    - 3 points for math
    - 1 point for answer
    - 1 point for dimensions
  - Part B (15 points)
    - 9 points for description
    - 6 points for math
    - 0 points for answer ☺
  - Part C (10 points)
    - 5 points for description
    - 3 points for math
    - 1 point for answer
    - 1 point for dimensions



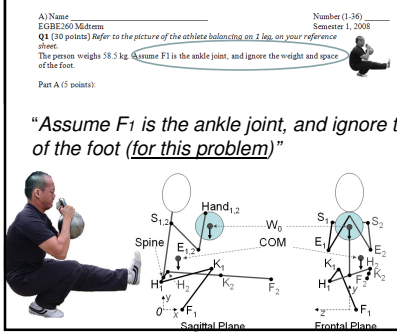
Important



Make sure your exam matches your handout

Otherwise you will get the wrong answer

Useful



"*Assume F1 is the ankle joint, and ignore the weight and space of the foot (for this problem)*"

Remember

- Do not write in red ink
- Turn off all cell phones
- Do not use any device which can communicate with the internet (PDA, Palm Pilot, etc…)
- I highly recommend a calculator for this exam (borrow one if necessary)

Review

- 3D Biomechanics problem, again, using different methods

3D Example

The baseball player weighs 80 kg, *(no height given)*.

The acceleration of the forearm and ball exert the following couple on the humerus bone:

$$M = -8\hat{i} + 5\hat{j} - 8\hat{k}$$

The rotator cuff muscles exert a -10 N-m couple parallel to the humerus going from the shoulder to the elbow.

Assume only 1 muscle acts at a proximal point 10% of the length of the humerus and 0.5 cm superior to center of the bone

Assume the muscle acts perpendicular to humerus

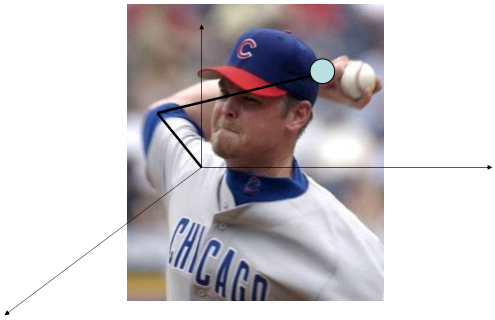
What force must that muscle generate?

Anthropometry

- Weight of arm: (.028)(80 kg) (9.81 m/s^2)= **22N**
- COM: = (0.436) * Arm vector + shoulder

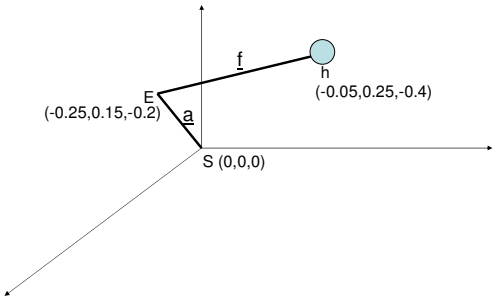
Segment	Segment Weight / Total Body Weight	Segment Length / Height		Proximal COM / Segment Length	
Upper Arm	2.8%	A	18.6%	A_1	43.6%
Forearm	1.6%	B	14.6%	B_1	43.0%
Hand	0.6%	C	10.8%	C_1	50.6%
Thigh	10.0%	D	24.5%	D_1	43.3%
Shank	4.7%	E	24.6%	E_1	43.3%
Foot	1.5%	F	3.9%	F_1	50.0%
Trunk	49.7%	G	34.0%	G_1	50.0%
Head & Neck	8.1%	H	18.2%		

Coordinates



17

Coordinates



18

Solution: What is the force?

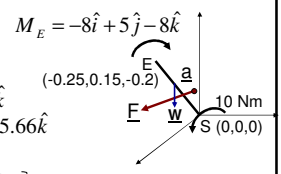
1) M_E $\underline{M}_E = -8\hat{i} + 5\hat{j} - 8\hat{k}$

2) M_S

$\underline{SE} = -0.25\hat{i} + 0.15\hat{j} - 0.2\hat{k}$

$\hat{e}_{SE} = -0.707\hat{i} + 0.424\hat{j} - 0.566\hat{k}$

$\underline{M}_S = -10\hat{e}_{SE} = 7.07\hat{i} - 4.24\hat{j} + 5.66\hat{k}$



3) M_W

$\underline{M}_W = \underline{r} \times \underline{W} = 0.436\underline{SE} \times \left(-22\hat{j}\right)$ } Different strategy

$$\underline{M}_W = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -.106 & .06 & -.085 \\ 0 & -20 & 0 \end{vmatrix}$$

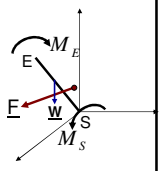
$\underline{M}_W = -1.7\hat{i} + 2.12\hat{k}$

Solution: What is the force?

$M_E = -8\hat{i} + 5\hat{j} - 8\hat{k}$

$M_S = 7.07\hat{i} - 4.24\hat{j} + 5.66\hat{k}$

$\underline{M}_W = -1.7\hat{i} + 2.12\hat{k}$



$\sum M_{point\,S} = M_S + M_E + M_F + M_W = 0$

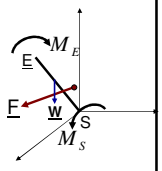
$M_F = 2.63\hat{i} - .76\hat{j} + 0.22\hat{k}$

Solution: What is the force?

$M_F = 2.63\hat{i} - .76\hat{j} + 0.22\hat{k}$

$M_F = \underline{r} \times \underline{F}$

$r = 0.1\underline{SE} + 0.005\hat{j} = -.025\hat{i} + 0.019\hat{j} - 0.2\hat{k}$



$$M_F = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -.025 & .019 & -0.02 \\ F_x & F_y & F_z \end{vmatrix}$$

$M_F = \left(0.019F_z + .02F_y\right)\hat{i} - \left(-.025F_z + 0.02F_x\right)\hat{j} + \left(-.025F_y - .019F_x\right)\hat{k}$

î: $0.019F_z + 0.02F_y = 2.63$

ĵ: $0.025F_z - 0.02F_x = -.76$

k: $-0.025F_y - 0.019F_x = 0.22$

This solution is never solvable

Equations are not independent

Infinite Number of Answers

Infinite Answers

- Last class: I added constraint: F_z=0 (easier to understand).
- This class: I added constraint: "Force acts perpendicular to humerus" (Less ambiguous)
- Understand that your 3 equations will never be solvable. Use whatever solution I give you. (I will either say set Fz equal to 0, or Force acts perpendicular or parallel to some axis or plane)

Force Acts Perpendicular

- If force acts perpendicular to humerus, use dot product:

$$\cos\theta = \frac{\underline{A}\cdot\underline{B}}{|\underline{A}||\underline{B}|}$$

$$0 = \frac{\underline{A}\cdot\underline{B}}{|\underline{A}||\underline{B}|}$$

$$\underline{A}\cdot\underline{B} = 0$$

$$\underline{F_M}\cdot\underline{SE} = 0 \qquad \underline{SE} = -0.25\hat{i} + 0.15\hat{j} - 0.2\hat{k}$$

$$-0.25F_{Mx} + 0.15F_{My} - 0.2F_{Mz} = 0$$

- This provides extra Equation. Now we can solve.
- Note: This is not the answer; it is 1 of the 3 necessary equations

Solving Equations

$\hat{i}$: 0.019F_z + 0.02F_y=2.63

$\hat{j}$: 0.025F_z - 0.02F_x= -.76

k: -0.025F_y - 0.019F_x=0.22

Perpendicular: -0.25 F_x + 0.15 F_y -0.2F_z = 0