This exam is closed book, closed notes. There are 4 section/questions, please write your name on each page.

Grade:

#1 _____ / 20

#3 _____ / 40

#4 _____ / 15

#5 _____ / 25

Final Grade ______ / 100
1. Complete the crossword puzzle using the clues. Each answer is worth 2 pts. **Total 20 pts**

**Across**
- 2. Movement away from the midline of the body *(abduction)*
- 8. Type of joint that allows large relative motion *(diarthrosis)*
- 10. Type of cartilage found at the end of long bones *(articular)*

**Down**
- 1. Type of fluid found in some joints *(synovial)*
- 3. Type of bone with a porosity of 50-95% *(trabecular)*
- 4. Connect muscle to bone *(tendon)*
- 5. Cavity if bone filled with yellow bone marrow *(medullary)*
- 6. Part of body furthest from the midline *(lateral)*
- 7. Density that is the ratio of mass of bone tissue to bulk volume *(apparent)*
- 9. Portion of the skeleton consisting of the skull, vertebral column, and thorax *(axial)*
3. Analyze the following images.

(a) Label the structures indicated by the boxes and arrows. **10 pts**

(b) Name the structures indicated by the boxes and arrows. **16 pts**

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**Microscopic Structure of Compact Bone**
(c) What does this image depict? What was the mechanism behind this injury? 6 pts

These images show stress fractures. These are the result of fatigue which is moderate levels of stress at high cycles. These types of fractures develop when there is not sufficient time between the cycles to allow the body time to repair the damage incurred during the loading.

(d) This graph looked at the strength of cortical bone in the femur of females. What does this graph tell you about the aging of bone? Why is there such a sharp increase in Young’s modulus in the over 70 group? 8 pts

This graph shows that as we age, bone becomes weaker which the compressive and tensile strengths indicate. It also shows that as we age our bone because more brittle which is indicated by the increase in Young’s modulus coupled with a decrease in overall strength (steep stress-strain curve).
4. This woman is doing a tricep curl with a 44.5 N weight beginning with her forearm and hand parallel with the floor. At the instant shown in Image A, the forearm and hand have an angular acceleration of 5 rad/sec². The woman has an overall \( h = 1.60 \) m and \( m = 60 \) kg. The weight is held a distance of 35.4 cm from elbow, which is it’s radius of gyration relative to the elbow. What is the moment generated at the elbow? **15 pts**

<table>
<thead>
<tr>
<th>Segment</th>
<th>Segment Length</th>
<th>Segment Weight/Total Body Weight</th>
<th>Center of Mass/Segment Length from Proximal</th>
<th>Radius of Gyration/Segment Length at Center of Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forearm and Hand</td>
<td>44 cm</td>
<td>0.022</td>
<td>0.682</td>
<td>0.468</td>
</tr>
</tbody>
</table>

\[
M_{FH} = 0.022 \times 60 \text{kg} = 1.32 \text{kg}
\]
\[
c_m = 0.682 \times (0.44 \text{m}) = 0.3 \text{m}
\]
\[
I_{FH} = m_{FH} c_m^2 = 1.32 \text{kg} \times (0.20 \text{m})^2 = 0.056 \text{kgm}^2
\]
\[
I_r = \frac{44.5 \text{N} \times (0.354 \text{m})^2}{9.81 \text{m/s}^2} = 0.568 \text{kgm}^2
\]
\[
\Sigma M_E = T_E \alpha
\]
\[
T_E = m_{FH} g (0.3 \text{m}) - W(0.35 \text{m}) = (I_{FH} + m d^2) \alpha + I_r \alpha
\]
\[
T_E = (I_{FH} + m d^2) \alpha + I_r \alpha + W(0.35 \text{m}) + m_{FH} g (0.3 \text{m})
\]
\[
T_E = (0.056 \text{kgm}^2 + 1.32 \text{kg}(0.3 \text{m})^2) \frac{5 \text{rad}}{s^2} + 0.568 \text{kgm}^2(5 \text{rad}/s^2) + 1.32 \text{kg}(9.8 \text{m/s}^2)(0.3) + 445 \text{N}(0.35 \text{m})
\]
\[
T_E = 23.2 \text{N}\text{m}
\]
5. (a) What does this graph tell us about the behavior of bone? 5 pts

This graph demonstrates the anisotropic behavior of bone. The bone is stronger and more ductile in the longitudinal direction while it is weaker and more brittle in the transverse direction.

(b) What motions are depicted by the images below? 10 pts

Abduction
Adduction
a. Supination
b. Pronation
Flexion

(c) Identify the plane of motion for the following motions: 5 pts

<table>
<thead>
<tr>
<th>Motion</th>
<th>Plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raising your arms out to the side</td>
<td>Frontal</td>
</tr>
<tr>
<td>Sit-ups</td>
<td>Sagittal</td>
</tr>
<tr>
<td>Squatting down</td>
<td>Sagittal</td>
</tr>
<tr>
<td>Shrugging your shoulder</td>
<td>Frontal</td>
</tr>
<tr>
<td>Turning your head</td>
<td>Transverse</td>
</tr>
</tbody>
</table>