Problem Set Answer Key
HST.021 Musculoskeletal Pathophysiology

1.
\[ W = mg \]
\[ |F_{ABx}| = |F_{AB}| \sin 30^\circ, \quad |F_{ABy}| = |F_{AB}| \cos 30^\circ \]
\[ F_j = F_{jx} + F_{jy} \]
\[ \Sigma F_x = 0 = -F_{ABx} + F_{jx} \quad (1) \]
\[ \Sigma F_y = 0 = -F_{ABy} + F_{jy} - 5W/6 \quad (2) \]
\[ \Sigma M = 0 = r \times F = rF \sin \theta \]
\[ M_o = 0 = b(5W/6) \sin(-90^\circ) + aF_{AB} \sin(90^\circ) \quad (3) \]

From (1), \( F_{jx} = F_{AB} \sin 30^\circ \)
From (2), \( F_{jy} = F_{AB} \cos 30^\circ + 5W/6 \)
From (3), \( F_{AB} = b(5W/6) = (15 \text{ cm})(5/6)(60 \text{ kg})(9.8 \text{ m/s}^2)/5 \text{ cm} \)

\[ F_{AB} = 1470 \text{ N} \]
\[ F_{jx} = (1470 \text{ N}) \sin 30^\circ = 735 \text{ N} \]
\[ F_{jy} = (1470 \text{ N}) \cos 30^\circ + (5/6)(60 \text{ kg})(9.8 \text{ m/s}^2) = 1763 \text{ N} \]
\[ F_j = (735 \text{ N})x + (1763 \text{ N})y = 1910 \text{ N}, \theta = 67.4^\circ \]

2.

<table>
<thead>
<tr>
<th>Osteoblast</th>
<th>Osteoclast</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) mesenchymal</td>
<td>a) monocyte/macrophage</td>
</tr>
<tr>
<td>b) bone deposition</td>
<td>b) resorption</td>
</tr>
<tr>
<td>c) PTH, IGF, estrogen, PTH-P, IL-1, IL-6, PDGF, vitamin D</td>
<td>c) calcitonin, some PTH, IL-6, integrins</td>
</tr>
<tr>
<td>d) mitochondria, vesicles, ER, single nucleus</td>
<td>d) multinucleated, proton pumps, microvilli, lysosomes</td>
</tr>
<tr>
<td>e) osteoporosis type II, from a reduction in osteoblasts</td>
<td>e) Paget’s osteoporosis type I, from a loss of estrogen leading to an increase in osteoclasts</td>
</tr>
</tbody>
</table>

3.

a) \( k = AE/L = \text{structural stiffness} \)
\[ E = (FL)/(A\Delta L) = \text{material stiffness} \]
\[ F = EA(\Delta L/L) = k\Delta L \]
\[ \delta = E\varepsilon \quad \text{(independent of geometry)} \]
\[ \rightarrow \text{per unit area, per unit length} \]

b)
4. 
   a) \( k = \frac{AE}{L} \)
   b) An increase in \( A \) would increase the stiffness whereas increase in the length would decrease the stiffness.
   c) \( \sigma = \frac{F}{A} \) \( \epsilon = \frac{\Delta L}{L} \)
      \[ F = AE(\Delta L/L) \rightarrow \frac{F}{A} = E(\Delta L/L) \rightarrow \sigma = E\epsilon \]
   d) yield stress and strain define the point at which permanent deformation occurs.
   ultimate stress and strain define the point at which failure occurs.