

Milestone 3 (Team) – Cover Page

Team Number:

6

Please list full names and MacID's of all *present* Team Members.

Full Name:	MacID:
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Any student that is ***not*** present for Design Studio will not be given credit for completion of the worksheet and may be subject to a 10% deduction to their DP-2 grade.

MILESTONE 3 (STAGE 2) – PRELIMINARY DESIGN ANALYSIS

FRACTURE RISK

Team Number: 6

Calculate the fracture risk of the implant stem assuming a combined loading scenario. Don't forget to:

- Compare tensile stress on the lateral side of the implant to the ultimate tensile strength of your assigned material
- Show all of your work neatly and in detail (do not skip steps), include the correct number of significant digits, and correct units

$$\begin{aligned} A_{\text{implant}} &= \frac{1}{4} \pi d^2 \quad | \quad d = 14 \text{ mm} \\ &= \frac{1}{4} \pi \left(\frac{14}{2} \right)^2 \\ &= \frac{361}{16} \pi \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} F &= 3.5 \times 103.5 \text{ kg} \cdot 9.81 \text{ m/s}^2 \\ &= 3,553.6725 \text{ N} \end{aligned}$$

$$\begin{aligned} \sigma &= \frac{F}{A} \\ &= \frac{3,553.6725 \text{ N}}{\frac{361}{16} \pi \text{ mm}^2} \\ &= 50.135 \text{ N/mm}^2 \end{aligned}$$

$$\begin{aligned} y &= 0.5 \cdot d \\ &= \frac{14}{2} \text{ mm} \end{aligned}$$

$$\begin{aligned} M &= F \cdot L \\ &= 3,553.6725 \text{ N} \cdot 8 \text{ mm} \\ &= 181237.2975 \text{ Nmm} \end{aligned}$$

$$\begin{aligned} I &= \frac{\pi}{64} \cdot d^4 \\ &= \frac{\pi}{64} \left(\frac{14}{2} \right)^4 \\ &= \frac{130321}{1024} \pi \text{ mm}^4 \end{aligned}$$

$$\begin{aligned} \sigma_B &= \frac{M \cdot y}{I} \\ &= 2153.162797 \end{aligned}$$

$$\begin{aligned}
 FR &= \frac{\sigma_{\text{total}}}{UTS_{\text{implant}}} \\
 &= \frac{\sigma_A + \sigma_B}{UTS_{\text{implant}}} \\
 &= \frac{50.135 \text{ N/mm}^2 + 2153.162747}{1010 \text{ MPa}}
 \end{aligned}$$

$$= 2.1814 \dots$$

$$= 2.2 \text{ (2 s.f.)} \quad \checkmark$$

MILESTONE 3 (STAGE 2) – PRELIMINARY DESIGN ANALYSIS

FATIGUE LIFE



Team Number: 6

Calculate the fatigue life of your assigned material.

→ Show all of your work neatly and in detail (do not skip steps), include the correct number of significant digits, and correct units

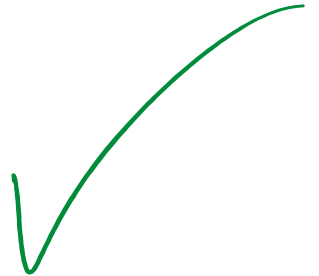
$$\begin{aligned}\sigma_{max} &= \frac{30 \cdot BW}{A} \\ &= \frac{30 \cdot (103.5 \text{ kg} \cdot 9.81 \text{ m/s}^2)}{\frac{361}{16} \pi \text{ mm}^2} \quad \text{from } \textcircled{\#1}\end{aligned}$$

$$= 429.7278692 \text{ N/mm}^2$$

$$\begin{aligned}\sigma_{min} &= -\sigma_{max} \\ &= -429.7278692 \text{ N/mm}^2\end{aligned}$$

$$\begin{aligned}\sigma_{avg} &= \frac{\sigma_{max} + \sigma_{min}}{2} \\ &= \frac{429.72... + (-429.72...)}{2} \\ &= 429.72... \\ &= 430 \text{ N/mm}^2 \text{ (to 2 s.f.)}\end{aligned}$$

∴ fatigue life would be 7×10^7 cycles



MILESTONE 3 (STAGE 2) – PRELIMINARY DESIGN ANALYSIS

BONE STRESS REDUCTION

Team Number: 6

Calculate the magnitude of bone stress reduction after implant reconstruction. Don't forget:

- Calculations should not consider a combined loading scenario, like in Part 1 of this Milestone
- Show all of your work neatly and in detail (do not skip steps), include the correct number of significant digits, and correct units

$$\begin{aligned} F &= BW \cdot 30 \\ &= 103.5 \text{ kg} \cdot 9.81 \text{ m/s}^2 \cdot 30 \\ &= 30460.05 \text{ N} \end{aligned} \qquad \begin{aligned} A &= \frac{\pi}{4} (D_o^2 - D_i^2) \\ &= \frac{\pi}{4} ((35 \text{ mm})^2 - (19 \text{ mm})^2) \\ &= 216 \pi \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \sigma_{\text{comp}} &= \frac{F}{A} \\ &= \frac{30460.05 \text{ N}}{216 \pi \text{ mm}^2} \\ &= 44.88766226 \end{aligned}$$

$$\begin{aligned} \sigma_{\text{reducer}} &= \sigma_{\text{comp}} \cdot \left(\frac{2 \cdot E_{\text{bone}}}{E_{\text{bone}} + E_{\text{imp}}} \right)^{\frac{1}{2}} \\ &= 16.49 \text{ N/mm}^2 \text{ (2 S.f.)} \end{aligned}$$