Model Answer Summer 2013
Mechanical Engineering
(ME 252) Final Exam

Question (1)

(a) Write short notes (7.5 Marks)

(i) Elasticity: (1.5)

هى قدرة المادة على إستعادة شكلها الأصلى أى عدم بقاء أى تشكل دائم بعد زوال الحمل المؤثر عليها.

(ii) Plasticity: (1.5)

هى قدرة المادة على الإحتفاظ بشكلها أى أنه يكون لها تشكيل دائم أى لا تعود المادة إلى شكلها الأصلى بعد إزالة الحمل عنها

(iii) Stiffness: (1.5)

هى خاصية مقاومة المادة لأى تغير فى الشكل وتقاس بمقدار معامل المرونة وهو قيمة الزيادة فى الإجهاد مقسومة على الزيادة فى الإنفعال المناظر له وذلك فى الجزء المستقيم من الرسم البيانى للحمل والإستطالة أو للإجهاد والإنفعال

$$E = \frac{P}{A} * \frac{L}{\Delta L} = \frac{\sigma}{\epsilon}$$

(IV) Resilience: (1.5)

هى قدرة المادة على إمتصاص الطاقة المرنة والتى تختفى تماماً بعد زوال الحمل المؤثر وتقدر بالشغل المبذول على العينة حتى حد التناسب أى أنه

$$Resilience = \frac{1}{2} P_{elastic} * \Delta L_{elastic}$$

(V) Toughness (1.5)

هى قدرة المادة على تحمل الأحمال الديناميكية أى مقدرتها على مقاومة الصدمات وامتصاص الطاقة الميكانيكية ويقصد بالمادة المتينة بأنها المادة التى تتحمل إجهاداً مناسباً مع تغير

كبير من الشكل بدون كسر. ويقدر بالشغل المبذول على العينة حتى الكسر، ويساوي المساحة أسفل منحنى الحمل والاستطالة

$$\text{Toughness} = \frac{P_{max} + P_y}{2} * \Delta L_f$$

(b) The problem: (7.5 Marks)

$E = 45 * 10^9 \ N/m^2$ ، $L_o = 3 \ m$

$\sigma_{yield} = 200 * 10^6 \ N/m^2$ ، $\sigma_{max} = 300 * 10^6 \ N/m^2$

$d_o = 12.5 * 10^{-3} \ m \Rightarrow A_o = \frac{\pi}{4} d_o^2 \Rightarrow A_o = 1.23 * 10^{-4} \ m^2$

Req ① P? to make $\Delta L = 6.25 * 10^{-3} \ m$

$$\because E = \frac{PL}{A \Delta L} \Rightarrow P = \frac{E A \Delta L}{L} = \frac{45*10^9 \ (N/m^2) * 1.23*10^{-4} \ (m^2) * 6.25*10^{-3} \ (m)}{3 \ (m)}$$

$$P = 11.53 * 10^3 \ \text{Newton}$$ (2.5)

② P_{yield}

$$\because \sigma_{yield} = \frac{P_{yield}}{A_o} \Rightarrow P_{yield} = 200*10^6 * 1.23*10^{-4}$$

$$P_{yield} = 24.6 * 10^3 \ \text{Newton}$$ (2.5)

③ P_{max}

$$\because \sigma_{max} = \frac{P_{max}}{A_o} \Rightarrow P_{max} = 300*10^6 * 1.23*10^{-4}$$

$$P_{max} = 36.9 * 10^3 \ \text{Newton}$$ (2.5)

Question (2)

$b = 10\ cm$, $E = 2 * 10^{6}\ kg/cm^{2}$

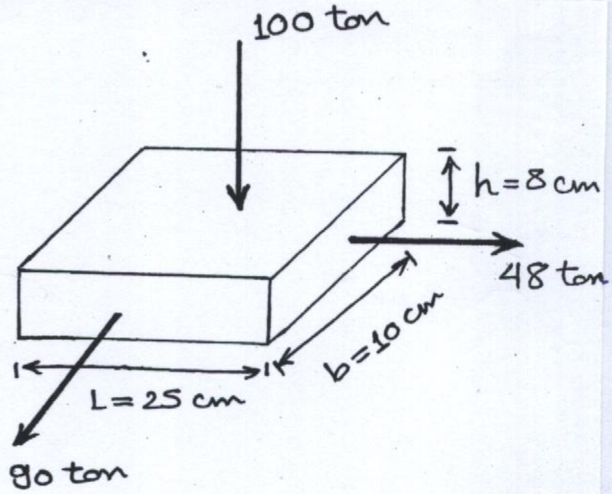
$h = 8\ cm$, $\mu = 0.25$

$L = 25\ cm$

$P_x = 48 * 10^{3}\ kg$

$P_y = -100 * 10^{3}\ kg$ (Compression)

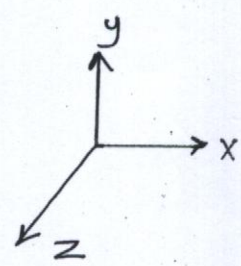
$P_z = 90 * 10^{3}\ kg$



$$\sigma_x = \frac{P_x}{A_x} = \frac{48 * 10^{3}}{10 * 8} = 600\ kg/cm^{2}$$ (2)

$$\sigma_y = \frac{P_y}{A_y} = \frac{-100 * 10^{3}}{10 * 25} = -400\ kg/cm^{2}$$ (2)

$$\sigma_z = \frac{P_z}{A_z} = \frac{90 * 10^{3}}{25 * 8} = 450\ kg/cm^{2}$$ (2)



$\because V = L * b * h = 25 * 10 * 8 = 2000\ cm^{3}$ (1)

$$\because \epsilon_v = \frac{\Delta V}{V} = \frac{\sigma_x + \sigma_y + \sigma_z}{E}(1 - 2\mu)$$ (2)

$$\Delta V = \frac{\overset{kg/cm^{2}}{600 - 400 + 450}}{\underset{kg/cm^{2}}{2 * 10^{6}}}(1 - 0.5) * \overset{cm^{3}}{2000}$$

$$\Delta V = 0.325\ cm^{3}$$ (1)

Question (3)

power = 80 kW , n = 250 r.p.m.

$T_{max} = 1.3\ T_{mean}$, $q_{max} = 70 * 10^6\ N/m^2$

Req D?

sol

$\because$ Power = $T * \omega$

$$80 * 10^3 = T * \frac{2\pi * n}{60}$$

$$T = \frac{80 * 10^3 * 60}{2\pi * 250}$$

$$T = 3055.77\ N.m$$ (2)

$\because T_{max} = 1.3\ T_{mean}$

$T_{max} = 1.3 * 3055.77$

$$T_{max} = 3972.5\ N.m$$ (2)

$$\because \frac{T_{max}}{J} = \frac{q_{max}}{R}$$

$$\frac{32\ T_{max}}{\pi\ D^4} = \frac{2\ q_{max}}{D}$$ (3)

$$D^3 = \frac{16\ T_{max}}{\pi\ q_{max}} = \frac{16 * 3972.5}{\pi * 70 * 10^6}$$

$$D = \sqrt[3]{\frac{16 * 3972.5}{\pi * 70 * 10^6}}$$

(3)

$\therefore D = 0.066\ m$

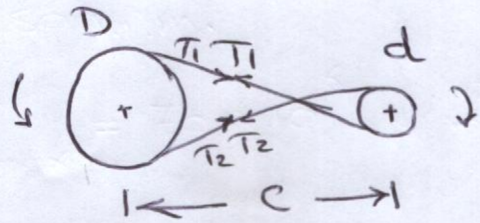
$D = 6.6\ cm$

Question (4)

$D = 0.4 \text{ m}$

$d = 0.15 \text{ m}$

$C = 2 \text{ m}$



$n_{large} = 250 \text{ r.p.m}$, $T_1 = 1000 \text{ N}$, $\mu = 0.4$

Req: θ , L , power

sol

$\because \theta = 180 + 2 \sin^{-1} \frac{D+d}{2C}$

$\theta = 180 + 2 \sin^{-1} \frac{0.4 + 0.15}{2*2}$

$$\theta = 195.8^\circ$$ (2)

$\theta_{rad} = 195.8 * \frac{\pi}{180} = 3.417$

$L = \sqrt{4C^2 - (D-d)^2} + \frac{\theta_{rad}}{2}(D+d)$

$L = \sqrt{4*4 - (0.4-0.15)^2} + \frac{3.417}{2}(0.4+0.15)$

$$L = 4.93 \text{ m}$$ (2)

$\because \frac{T_1 - T_c}{T_2 - T_c} = e^{\mu \theta_{rad}}$ (1)

$\because T_c$ has no givens (ρ or A)

$\therefore T_c$ is neglected (1)

$\therefore \frac{T_1}{T_2} = e^{\mu \theta_{rad}}$

$$\therefore \frac{1000}{T_2} = e^{0.4*3.417}$$

$$T_2 = 254.92 \text{ N}$$ (1)

$$\because V = \frac{\pi D n_{large}}{60} = \frac{\pi * 0.4 * 250}{60}$$

$$v = 5.24 \text{ m/S}$$ (1)

$$\because \text{power} = (T_1 - T_2) \, v$$ (1)

$$\text{power} = (1000 - 254.92) * 5.24$$

$$\text{power} = 3904.22 \text{ watt}$$ (1)

Question (5)

(a) Define (3 Marks)

(i) System: (1)

A quantity of matter or a region in space chosen for study.

(ii) Boundary: (1)

is a real or imaginary surface that separates the system from its surrounding.

(iii) Cycle: (1)

series of Processes in which the initial state of the system is the final state; a system is said to have undergone a cycle if it returns to its initial state at the end of the process.

(b) Difference: (2 Marks)

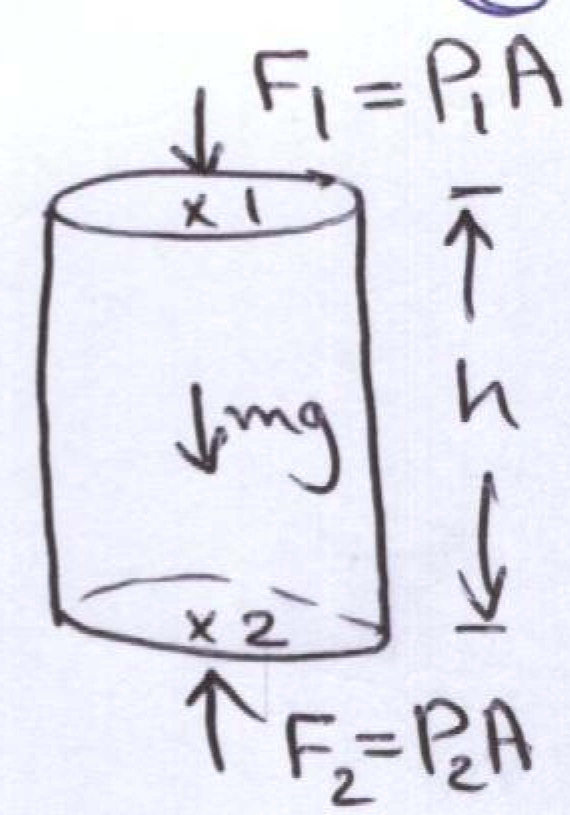
(1) Intensive properties: those are independent of the mass of the system (T or P, ρ)

(2) Extensive properties: those are depend on the size of the system (m, V)

(c) $\Delta T_C = \Delta T_K = 30^\circ C \Rightarrow 30\,K$ (1 Mark)

(d) Prove: (2 Marks)

$$\rho = \frac{m}{V} \Rightarrow m = \rho V = \rho A h$$



$$\sum F_y = 0$$

$$F_2 - F_1 - mg = 0$$

$$P_2 A - P_1 A - \rho A h g = 0$$

Divide by (A)

$$P_2 - P_1 - \rho h g = 0$$

$$\therefore P_2 - P_1 = \rho g h \Rightarrow \Delta P = \rho g h$$

(e) problem (3 Marks)

$$P_g = 400 \text{ kPa} , \quad P_{atm} = 1 \text{ bar} = 100 \text{ kPa}$$

$$\therefore P_{abs} = P_g + P_{atm} = 400 + 100$$

$$P_{abs} = 500 \text{ kPa}$$

(f) Problem (4 Marks)

$$P_{bottom} = \rho g h)_{mercury} = 13600 * 9.8 * 0.76$$

$$P_{bottom} = 101292.8 \text{ pascal}$$

$$\therefore P_{botton} - P_{top} = \rho g h)_{air}$$

$$P_{top} = 101292.8 - (1 * 9.8 * 45)$$

$$P_{top} = 100851.8 \text{ pascal}$$

$$\therefore P_{top} = \rho g h)_{mercury\ at\ top}$$

$$100851.8 = 13600 * 9.8 * h_{mercury} \Rightarrow h = 0.757 \text{ mHg}$$