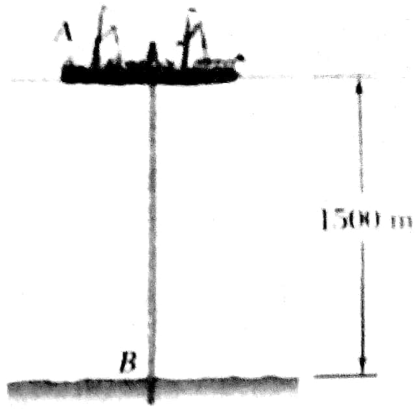
Mansoura University
Faculty of Engineering
Prod. Eng. & Mech. Design Dept.
Mid Term Exam (Second Time)

Level 100 –BME & MTE Eng. Dept.
PDE181 - Strength of Materials
40 Marks - 2 Hours
Date: 12/1/2016

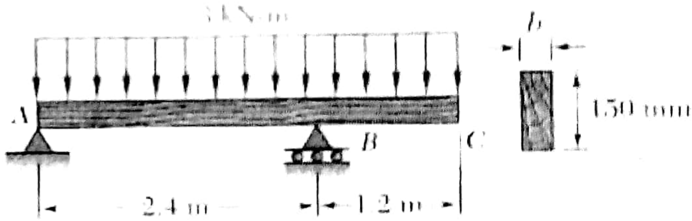
Question One: (10 Marks)

The ship at A has just started to drill for oil on the ocean floor at a depth of 1500 m. Knowing that the top of 200 mm diameter steel drill pipe (G = 77.2 GPa) rotates through two complete revolutions before the drill bit at B starts to operate, determine the maximum shearing stress caused in the pipe by torsion.



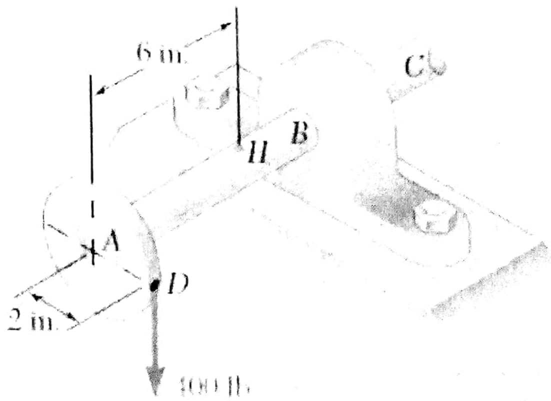
Question Two: (15 Marks)

For the beam and loading shown, design the cross section of the beam, knowing that the grade of timber used has an allowable normal stress of 12 MPa.



Question Three (15 Marks)

A 400 Ib vertical force is applied at D to a gear attached to the solid 1 in diameter shaft AB. Determine the principal stresses and the maximum shearing stress at point H located as shown on the top of the shaft.



Good Luck
Assoc. Prof. Dr. Noha Fouda

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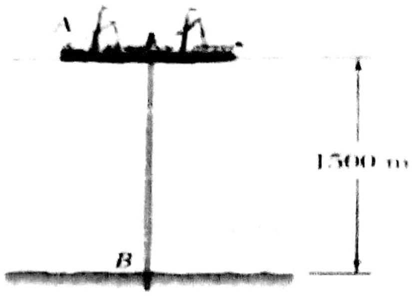
Question (1)

The ship at A has just started to drill for oil on the ocean floor at a depth of 1500 m. Knowing that the top of the 200-mm-diameter steel drill pipe (G = 77.2 GPa) rotates through two complete revolutions before the drill bit at B starts to operate, determine the maximum shearing stress caused in the pipe by torsion.



$$\emptyset = \frac{T\,L}{J\,G}$$

$$T = \frac{\emptyset\,J\,G}{L}$$

$$\tau = \frac{T\,C}{J} = T \cdot \frac{C}{J}$$

$$= \frac{\emptyset\,J\,G}{L} \cdot \frac{C}{J}$$

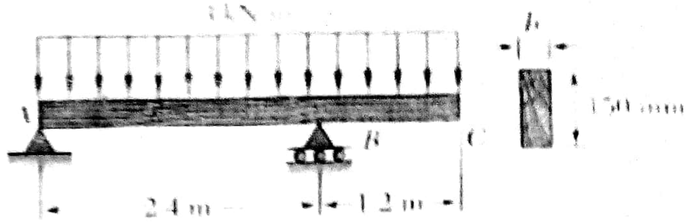
$$= \frac{\emptyset\,G\,C}{L}$$

$$= \frac{(2 * 2\,\pi) * (77.2 * 10^{9}) * (100 * 10^{-3})}{1500}$$

$$= 64.7\ MPa$$

Question (2)

For the beam and loading shown, design the cross section of the beam, knowing that the grade of timber used has an allowable normal stress of 12 MPa.



حساب (reactions) بتطبيق معادلات الاتزان

$$+\uparrow \sum F_y = 0$$

$$A_y + B_y - 3 * 3.6 = 0$$

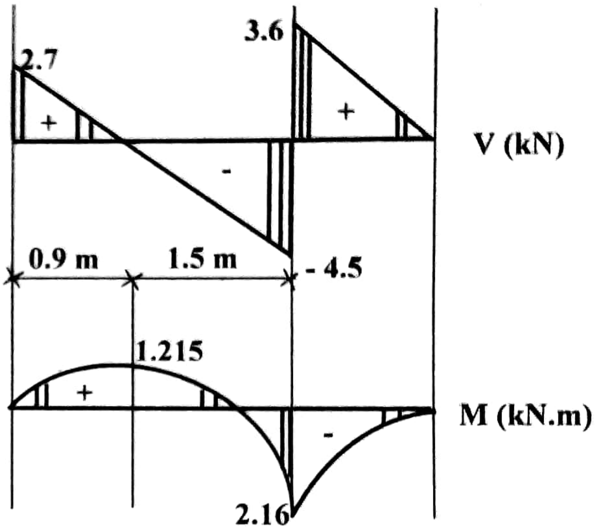
$$A_y + B_y = 10.8 \ kN$$

$$\circlearrowright + \sum M_A = 0$$

$$-3 * 3.6 * 1.8 + B_y * 2.4 = 0$$

$$B_y = 8.10 \ kN$$

$$A_y = 2.70 \ kN$$



لرسم M: نبدأ عند أقصى اليسار من الصفر ونحسب مساحات الأشكال المنتظمة في منحنى **(V-diagram)** ثم نقوم بتمثيلها في منحنى **(M-diagram)** حسب إشارتها ويكون **(M)** عند كل نقطة تالية:

$$M_{new} = M_{previous} + A_v$$

مع مراعاة أن نبدأ عند أقصى اليسار من الصفر وننتهي عند أقصى اليمين بقيمة الصفر أيضاً.

لرسم V: نبدأ من أقصى اليسار ونصعد مع كل قوة لأعلى بنفس قيمتها، وننزل مع كل قوة لأسفل بنفس قيمتها ويكون الصعود أو النزول بنفس النقطة إذا كانت القوة **(concentrated)**، ويكون خطياً إذا كانت القوة **(distributed)**، مع مراعاة أن نبدأ عند أقصى اليسار من الصفر وننتهي عند أقصى اليمين بقيمة الصفر أيضاً.

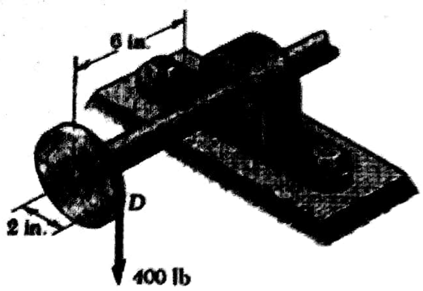
$$\sigma = \frac{M\,c}{I}$$

$$12 * 10^6 = \frac{(2.16 * 10^3) * (75 * 10^{-3})}{\frac{1}{12} * b * (150 * 10^{-3})^3}$$

$$b = 48 \ mm$$

Question (3)

A 400-lb vertical force is applied at D to a gear attached to the solid one-inch diameter shaft AB. Determine the principal stresses and the maximum shearing stress at point H located as shown on top of the shaft.



SOLUTION

Equivalent force-couple system at center of shaft in section at point H.

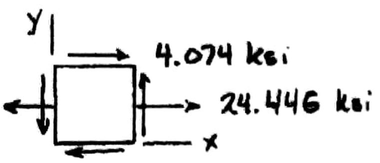
$V = 400$ lb. $\quad M = (400)(6) = 2400$ lb·in
$T = (400)(2) = 800$ lb·in.

Shaft cross section. $\quad d = $ in $\quad c = \frac{1}{2}d = 0.5$ in
$J = \frac{\pi}{2}c^4 = 0.098175$ in^4 $\quad I = \frac{1}{2}J = 0.049087$ in^4

Torsion: $\quad \tau = \frac{Tc}{J} = \frac{(800)(0.5)}{0.098175} = 4.074 \times 10^3$ psi $= 4.074$ ksi

Bending: $\quad \sigma = \frac{Mc}{I} = \frac{(2400)(0.5)}{0.049087} = 24.446 \times 10^3$ psi $= 24.446$ ksi

Transverse shear: Stress at point H is zero.



$\sigma_x = 24.446$ ksi $\quad \sigma_y = 0 \quad \tau_{xy} = 4.074$ ksi

$\sigma_{ave} = \frac{1}{2}(\sigma_x + \sigma_y) = 12.223$ ksi

$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} = \sqrt{(12.223)^2 + (4.074)^2}$

$= 12.884$ ksi

$\sigma_a = \sigma_{ave} + R = 25.107$ ksi

$\sigma_b = \sigma_{ave} - R = -0.661$ ksi

$\tau_{max} = R = 12.884$ ksi