Document No : UniKL MFI_SD_AC41
Revision No: 02
Effective Date: 01 December 2008

CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION

SEPTEMBER 2014 SESSION

SUBJECT CODE	:	**FMB12203**
SUBJECT TITLE	:	**STRENGTH OF MATERIALS**
LEVEL	:	**BACHELOR**
TIME / DURATION	:	**2.00 PM – 5.00 PM (3 HOURS)**
DATE	:	**7 JANUARY 2015**

INSTRUCTIONS TO CANDIDATES

1. **Please read the instructions given in the question paper CAREFULLY.**
2. **This question paper is printed on both sides of the paper.**
3. **Please write your answers on the answer booklet provided.**
4. **Answer should be written in blue or black ink except for sketching, graphic and illustration.**
5. **This question paper consists of 5 questions. Choose and answer 4 questions only.**
7. **Formulae sheets are appended.**

THERE ARE 5 PAGES OF QUESTIONS AND 2 PAGES OF FORMULAE, EXCLUDING THIS PAGE.

INSTRUCTION: Answer FOUR (4) questions only.
Answer on the answer booklet provided.

Question 1

The frame is subjected to the load of *4 kN* which acts on member ABD at D, as shown in *Figure 1* below. Pin C is subjected to *double shear*, whereas pin D is subjected to *single shear* and the allowable shear stress for the material is τ_{allow} = *40 MPa*.

a) Determine the required diameter of the pins at C

(13 marks)

b) Determine the required diameter of the pins at D

(12 marks)

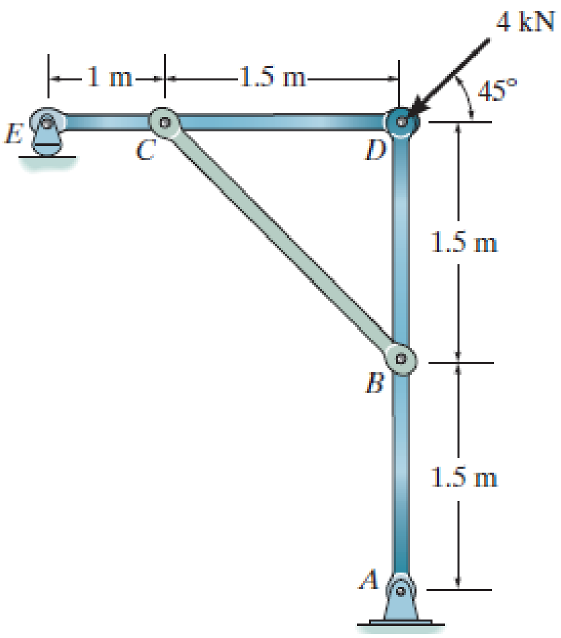


Figure 1

Question 2

The pin-connected rigid rods AB and BC, as shown in *Figure 2* below are inclined at $\theta = 30^o$ when they are unloaded. When the force P is applied, θ becomes *30.2°*.

a) Determine the length of wire AC before the load P applied

(10 marks)

b) Determine the length of wire AC after the load P applied

(10 marks)

c) Determine the average normal strain developed in wire AC

(5 marks)

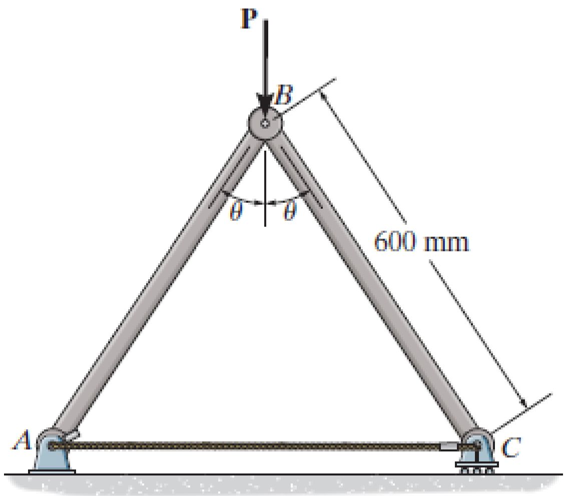


Figure 2

Question 3

A tension test was performed on a steel specimen having an original diameter of *12.5 mm* and gauge length of *50 mm*. The data is listed in the *Table 1* below. Use a scale of 25 mm 140 MPa and 25 mm= 0.05 mm/mm. Redraw the elastic region, using the same stress scale but a strain scale of 25 mm= 0.001 mm/mm.

a) Plot the stress–strain diagram

(13 marks)

b) Determine approximately the modulus of elasticity, the yield stress, the ultimate stress, and the rupture stress.

(12 marks)

Table 1

Load (kN)	**Elongation (mm)**
0.0	0.0
7.0	0.0125
21.0	0.0375
36.0	0.0625
50.0	0.0875
53.0	0.125
53.0	0.2
54.0	0.5
75.0	1.0
90.0	2.5
97.0	7.0
87.8	10.0
83.3	11.5

Question 4

The *150-mm*-diameter shaft is supported by a smooth journal bearing at E and a smooth thrust bearing at F, as shown in *Figure 3* below.

a) Determine the maximum shear stress developed in each segment of the shaft.

(13 marks)

b) Determine the required minimum wall thickness of the shaft, if the shaft has an outer diameter of *150 mm* and made from material having an allowable shear stress of *85 MPa*.

(12 marks)

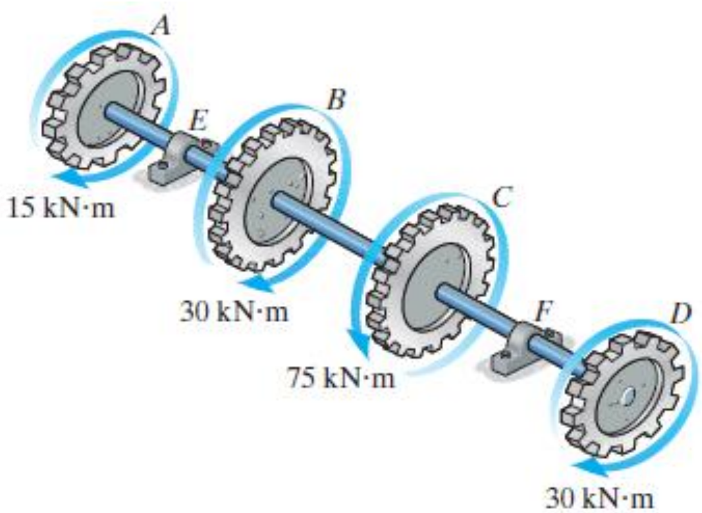


Figure 3

Question 5

Beam AB with 2 supports is shown in *Figure 4* below. A concentrated and a distributed force is applied to the respective beam AB.

a) Express the internal shear and moment in terms of x.

(15 marks)

b) Draw the shear and moment diagrams for the beam AB.

(10 marks)

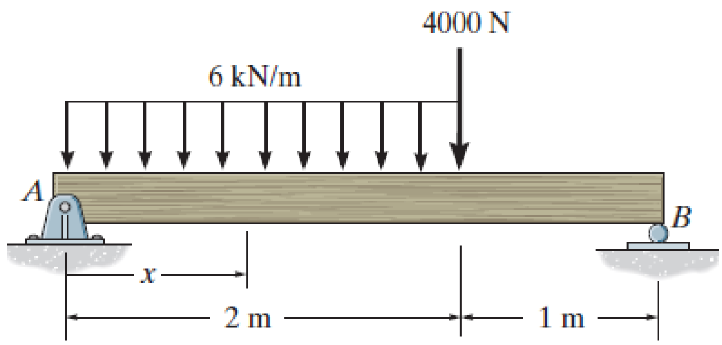


Figure 4

END OF QUESTION PAPER

Formulae

Axial Load

Normal Stress

$$\sigma = \frac{P}{A}$$

Displacement

$$\delta = \int_0^L \frac{P(x)dx}{A(x)E}$$

$$\delta = \Sigma \frac{PL}{AE}$$

$$\delta_T = \alpha \, \Delta T L$$

Torsion

Shear stress in circular shaft

$$\tau = \frac{T\rho}{J}$$

where

$$J = \frac{\pi}{2} c^4 \quad \text{solid cross section}$$

$$J = \frac{\pi}{2}(c_o^4 - c_i^4) \quad \text{tubular cross section}$$

Power

$$P = T\omega = 2\pi f T$$

Angle of twist

$$\phi = \int_0^L \frac{T(x)dx}{J(x)G}$$

$$\phi = \Sigma \frac{TL}{JG}$$

Average shear stress in a thin-walled tube

$$\tau_{avg} = \frac{T}{2tA_m}$$

Shear Flow

$$q = \tau_{avg} t = \frac{T}{2A_m}$$

Bending

Normal stress

$$\sigma = \frac{My}{I}$$

Unsymmetric bending

$$\sigma = -\frac{M_z y}{I_z} + \frac{M_y z}{I_y}, \qquad \tan \alpha = \frac{I_z}{I_y} \tan \theta$$

Shear

Average direct shear stress

$$\tau_{avg} = \frac{V}{A}$$

Transverse shear stress

$$\tau = \frac{VQ}{It}$$

Shear flow

$$q = \tau t = \frac{VQ}{I}$$

Stress in Thin-Walled Pressure Vessel

Cylinder

$$\sigma_1 = \frac{pr}{t} \qquad \sigma_2 = \frac{pr}{2t}$$

Sphere

$$\sigma_1 = \sigma_2 = \frac{pr}{2t}$$

Stress Transformation Equations

$$\sigma_{x'} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2} \cos 2\theta + \tau_{xy} \sin 2\theta$$

$$\tau_{x'y'} = -\frac{\sigma_x - \sigma_y}{2} \sin 2\theta + \tau_{xy} \cos 2\theta$$

Principal Stress

$$\tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x - \sigma_y)/2}$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Maximum in-plane shear stress

$$\tan 2\theta_s = -\frac{(\sigma_x - \sigma_y)/2}{\tau_{xy}}$$

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

$$\sigma_{avg} = \frac{\sigma_x + \sigma_y}{2}$$

Absolute maximum shear stress

$$\tau_{\substack{abs\\max}} = \frac{\sigma_{max}}{2} \quad \text{for } \sigma_{max}, \sigma_{min} \text{ same sign}$$

$$\tau_{\substack{abs\\max}} = \frac{\sigma_{max} - \sigma_{min}}{2} \quad \text{for } \sigma_{max}, \sigma_{min} \text{ opposite signs}$$

Material Property Relations

Poisson's ratio

$$\nu = -\frac{\epsilon_{\text{lat}}}{\epsilon_{\text{long}}}$$

Generalized Hooke's Law

$$\varepsilon_x = \frac{1}{E}\left[\sigma_x - \nu(\sigma_y + \sigma_z)\right]$$

$$\varepsilon_y = \frac{1}{E}\left[\sigma_y - \nu(\sigma_x + \sigma_z)\right]$$

$$\varepsilon_z = \frac{1}{E}\left[\sigma_z - \nu(\sigma_x + \sigma_y)\right]$$

$$\gamma_{xy} = \frac{1}{G}\tau_{xy},\quad \gamma_{yz} = \frac{1}{G}\tau_{yz},\quad \gamma_{zx} = \frac{1}{G}\tau_{zx}$$

where

$$G = \frac{E}{2(1+\nu)}$$

Relations Between w, V, M

$$\frac{dV}{dx} = w(x), \qquad \frac{dM}{dx} = V$$

Elastic Curve

$$\frac{1}{\rho} = \frac{M}{EI}$$

$$EI\frac{d^4v}{dx^4} = w(x)$$

$$EI\frac{d^3v}{dx^3} = V(x)$$

$$EI\frac{d^2v}{dx^2} = M(x)$$

Buckling

Critical axial load

$$P_{\text{cr}} = \frac{\pi^2 EI}{(KL)^2}$$

Critical stress

$$\sigma_{\text{cr}} = \frac{\pi^2 E}{(KL/r)^2},\ r = \sqrt{I/A}$$

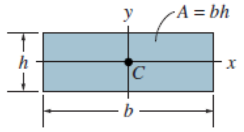
Secant formula

$$\sigma_{\max} = \frac{P}{A}\left[1 + \frac{ec}{r^2}\sec\left(\frac{L}{2r}\sqrt{\frac{P}{EA}}\right)\right]$$

Energy Methods

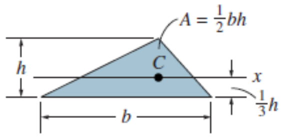
Conservation of energy

$$U_e = U_i$$



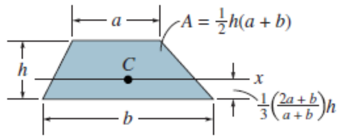
Rectangular area

$$I_x = \frac{1}{12}bh^3 \qquad I_y = \frac{1}{12}hb^3$$



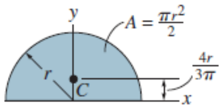
Triangular area

$$I_x = \frac{1}{36}bh^3$$



$\frac{1}{3}\left(\frac{2a+b}{a+b}\right)h$

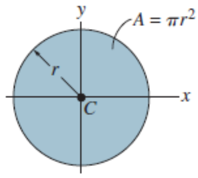
Trapezoidal area



$A = \frac{\pi r^2}{2}$, $\frac{4r}{3\pi}$

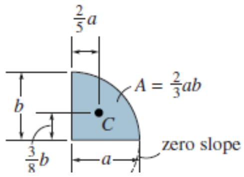
Semicircular area

$$I_x = \frac{1}{8}\pi r^4 \qquad I_y = \frac{1}{8}\pi r^4$$



Circular area

$$I_x = \frac{1}{4}\pi r^4 \qquad I_y = \frac{1}{4}\pi r^4$$



$\frac{2}{5}a$, $A = \frac{2}{3}ab$, $\frac{3}{8}b$

Average Mechanical Properties of Typical Engineering Materials[a]

(SI Units)

Materials		Density ρ (Mg/m³)	Moduls of Elasticity E (GPa)	Modulus of Rigidity G (GPa)	Yield Strength (MPa) σ_Y Tens.	Comp.[b]	Shear	Ultimate Strength (MPa) σ_u Tens.	Comp.[b]	Shear	%Elongation in 50 mm specimen	Poisson's Ratio ν	Coef. of Therm. Expansion α (10⁻⁶)/°C
Metallic													
Aluminum Wrought Alloys	2014-T6	2.79	73.1	27	414	414	172	469	469	290	10	0.35	23
	6061-T6	2.71	68.9	26	255	255	131	290	290	186	12	0.35	24
Cast Iron Alloys	Gray ASTM 20	7.19	67.0	27	–	–	–	179	669	–	0.6	0.28	12
	Malleable ASTM A-197	7.28	172	68	–	–	–	276	572	–	5	0.28	12
Copper Alloys	Red Brass C83400	8.74	101	37	70.0	70.0	–	241	241	–	35	0.35	18
	Bronze C86100	8.83	103	38	345	345	–	655	655	–	20	0.34	17
Magnesium Alloy	[Am 1004-T61]	1.83	44.7	18	152	152	–	276	276	152	1	0.30	26
Steel Alloys	Structural A-36	7.85	200	75	250	250	–	400	400	–	30	0.32	12
	Structural A992	7.85	200	75	345	345	–	450	450	–	30	0.32	12
	Stainless 304	7.86	193	75	207	207	–	517	517	–	40	0.27	17
	Tool L2	8.16	200	75	703	703	–	800	800	–	22	0.32	12
Titanium Alloy	[Ti-6Al-4V]	4.43	120	44	924	924	–	1,000	1,000	–	16	0.36	9.4