UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF MARINE ENGINEERING TECHNOLOGY

FINAL EXAMINATION
JANUARY 2016 SESSION

COURSE CODE	:	LGB 21103
COURSE NAME	:	STRENGTH OF MATERIALS
LEVEL	:	BACHELOR
DATE	:	30 MAY 2016
TIME	:	09.00AM – 12.00PM
DURATION	:	3 HOURS

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 given answer sheets.
4. Answers should be written in blue or black ink except for sketches, graphics and illustrations.
5. This question paper consists of ONLY ONE (1) section with SIX (6) questions. Answer FOUR (4) questions ONLY.
6. Answer all questions in English.
7. Graph paper is provided together with the answer sheets.
8. Formula sheet and stress concentration charts are attached with this question paper.

THERE ARE 8 PRINTED PAGES INCLUDING THIS COVER PAGE

SECTION A (Total: 100 marks)

INSTRUCTION: Answer FOUR (4) questions ONLY.
Please use the answer booklet provided.

Question 1

(a) One method of specifying the allowable load P for the design is the use the Factor of Safety (F.S.). In your own words describe the factor of safety and **give three (3) reasons** why F.S. is introduced.

(6 marks)

(b) Define the following terms:

i) Body Force. (2 marks)

ii) Surface Force. (2 marks)

(c) Figure 1 shows an open square butt joint that is used to transmit a force of 250N from one plate to another. Determine the following:

i) Internal forces acting on the face of the weld at sections AB and CD.

(3 marks)

ii) Average normal stress and average shear stress that acts on section AB.

(6 marks)

iii) Average normal stress and average shear stress that acts on section CD.

(6 marks)

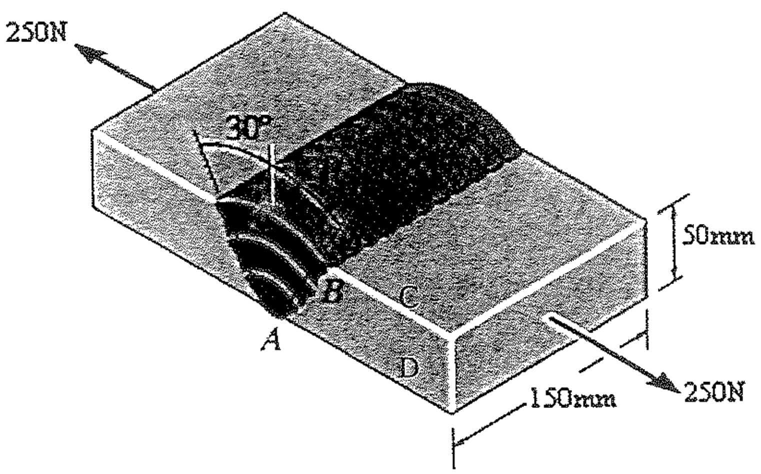

Figure 1: Open Square Butt Joint

Question 2

(a) Define the following terms:

i) Shear Strain. (2 marks)

ii) Small Strain Analysis. (3 marks)

(b) A block is deformed into the position shown by the dashed lines as shown in Figure 2. Calculate the following:

i) Average normal strain along the line AB and side OE. (14 marks)

ii) The average shear strain at A and D. (6 marks)

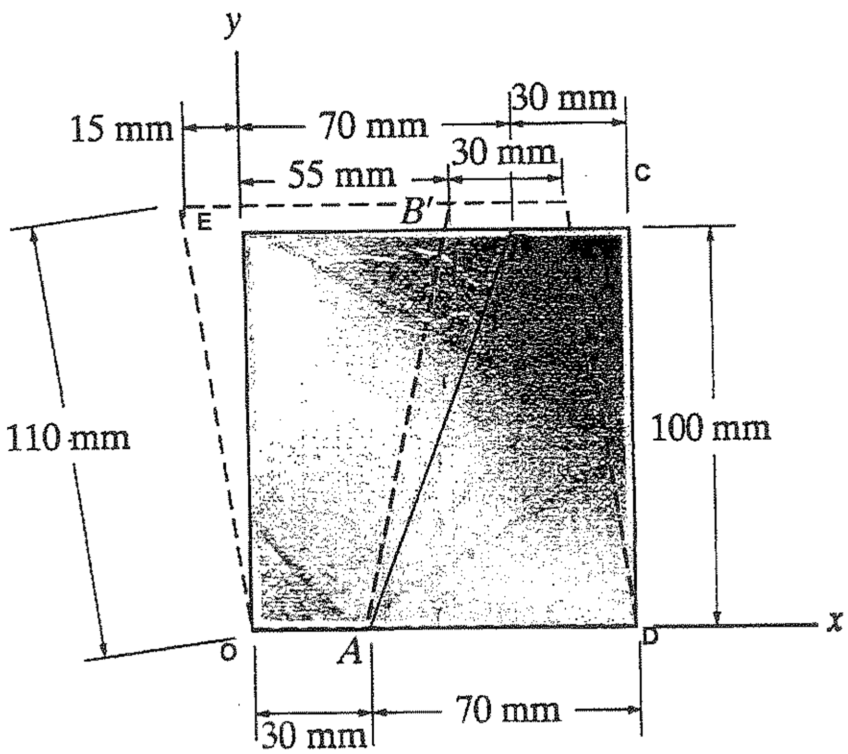

Figure 2: Deformed Block

Question 3

(a) Creep is a time-dependent deformation of a material while under an applied load that is below its yield strength. With an aid of a diagram, describe **three (3) regions** during creep extension process.

(10 marks)

(b) A tension test was performed on a steel specimen having an original diameter of 13mm and a gauge length of 50mm. The data is listed in Table 1 below. Plot a conventional stress-strain diagram and determine approximately the value of the following parameters:

i) Modulus of Elasticity (Young's Modulus).
ii) Yield Stress.
iii) Ultimate Stress.
iv) Failure Stress (Rupture Stress).

Table 1: Stress-Strain Data for a Steel Specimen

Load (kN)	Elongation (mm)
0.0	0.0000
7.5	0.0125
23.0	0.0375
40.0	0.0625
55.0	0.0875
59.0	0.1250
59.0	0.2000
60.0	0.5000
83.0	1.0000
100.0	2.5000
107.5	7.0000
97.5	10.0000
92.5	11.5000

(15 marks)

Question 4

(a) In your own words and with the aid of diagrams, describe the Principle of Superposition and state **two (2) conditions** needed in applying the principle.

(10 marks)

(b) A steel plate has a thickness of 12mm with shoulder fillets located at B and C as shown in Figure 3 below. Allowable stress is given as σ_{allow} =150MPa. Determine the following:

i) The maximum axial load P that the steel plate can support.

(5 marks)

ii) Its elongation, neglecting the effect of the fillets

(5 marks)

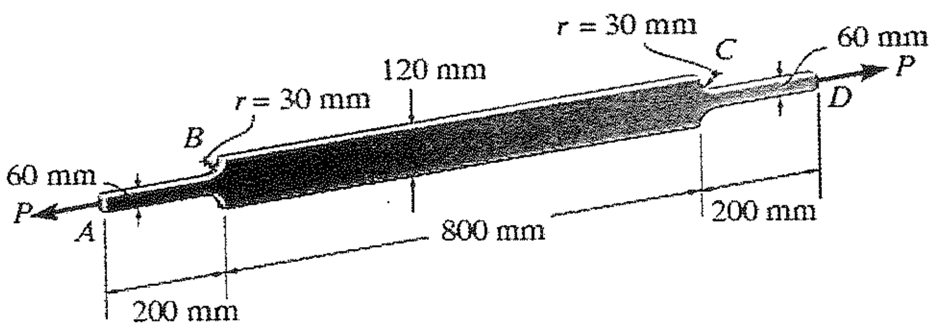

Figure 3: Steel Plate with Shoulder Fillets

(c) State **two (2)** stress concentration factor dependencies and give **three (3)** measures that can be employed to reduce stress concentration at discontinuities.

(5 marks)

Question 5

From the beam shown in Figure 4 below:

(a) Replace the distributed load by an equivalent resultant force and reactions.

(b) Draw the free body diagram of the beam segment of length *x*.

(c) Determine the shear and moment equations.

(25 marks)

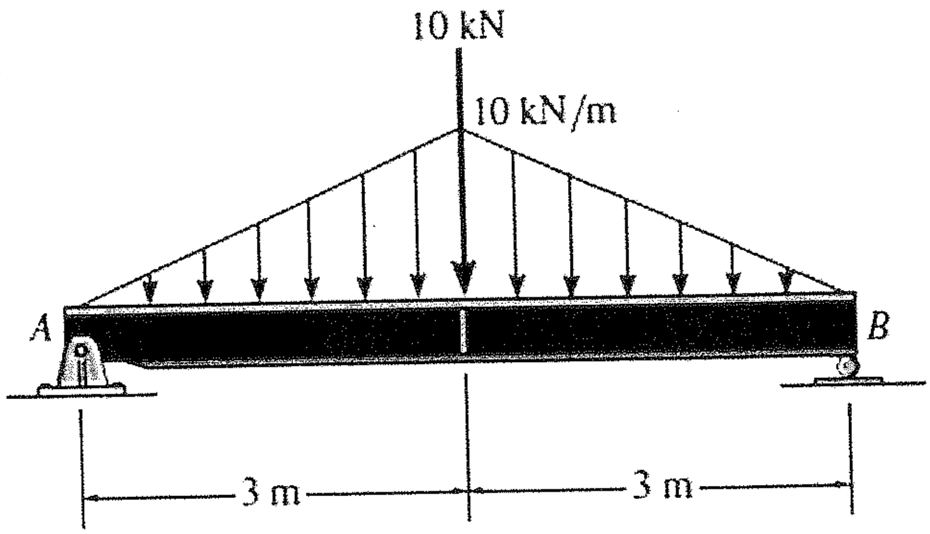

Figure 4: Distributed load applied to a simply supported beam

Question 6

(a) The steel axle is made from tubes AB and CD and a solid section BC. It is supported on smooth bearings that allow it to rotate freely as shown in Figure 5 below. The gear, fixed to its ends, are subjected to 85Nm of torques. The tubes have an outer diameter of 30mm and an inner diameter of 20mm. The solid section has a diameter of 40mm. Determine the angle of twist of gear A relative to gear D. Take G_{steel} as 75GPa.

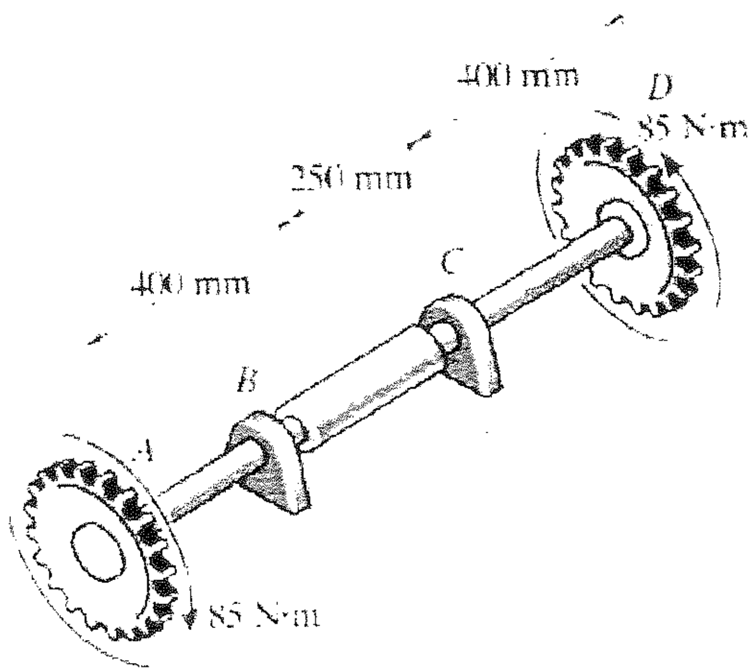

Figure 5: Steel axle and gear assembly

(10 marks)

(b) A motor delivers 33kW to the solid stainless steel shaft while it rotates at 20Hz. The solid shaft is supported on smooth bearings at A and B which allows free rotation of the shaft as shown in Figure 6 below. The gears C and D remove 20kW and 12kW respectively. Determine the **diameter** of the shaft to the nearest mm if the allowable shear stress is τ_{allow} = 56MPa and the allowable angle of twist of C with respect to D is 0.20^0. Take G_{ss} as 75GPa.

(15 marks)

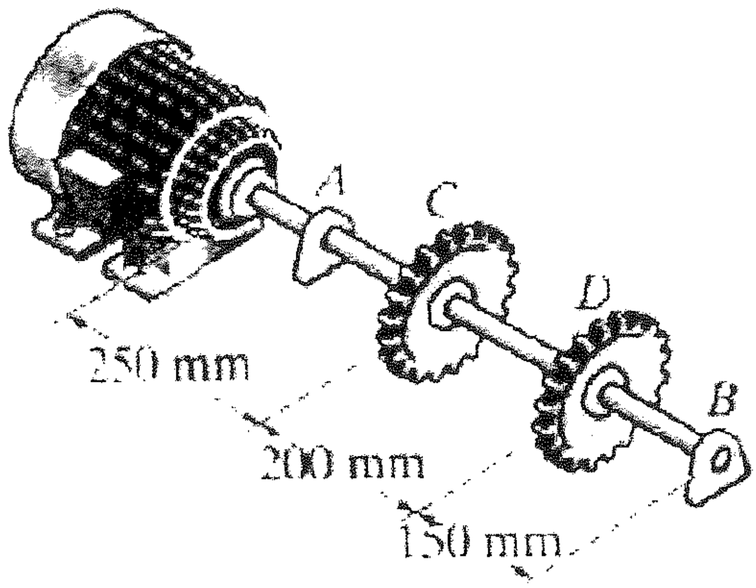

Figure 6: Motor-Gear assembly

END OF QUESTION PAPER

Normal Stress	$\sigma = \frac{P}{A}$
Shear Stress	$\tau = \frac{V}{A}$
Factor of Safety	$F.S. = \frac{F_{fail}}{F_{allow}} = \frac{\sigma_{fail}}{\sigma_{allow}} = \frac{\tau_{fail}}{\tau_{allow}}$
Average normal strain	$\varepsilon_{avg} = \frac{\Delta s' - \Delta s}{\Delta s}$
Shear strain	$\gamma = \frac{\pi}{2} - \theta'$
If θ is small	$\sin\theta \approx \theta$ $\cos\theta \approx 1$ $\tan\theta \approx \theta$
Pythagoras theorem	$a^2 = b^2 + c^2$
Cosine rule	$a^2 = b^2 + c^2 - 2bc\cos\theta$
Strain	$\varepsilon = \frac{\delta}{L_0}$
Hooke's Law (Normal)	$\sigma = E\varepsilon$
Hooke's Law (Shear)	$\tau = G\gamma$
Strain Energy	$u = \frac{1}{2}\sigma\varepsilon = \frac{1\sigma^2}{2E}$
Poisson's Ratio	$\upsilon = -\frac{\varepsilon_{lateral}}{\varepsilon_{longitudinal}}$
Lateral strain	$\varepsilon_{lateral} = \frac{\delta'}{r_0}$
Longitudinal strain	$\varepsilon_{longitudinal} = \frac{\delta}{L_0}$
Modulus of Elasticity	$E = \frac{\sigma}{\varepsilon}$
Modulus of Rigidity	$G = \frac{E}{2(1+\upsilon)}$

Displacement	$\delta = \frac{PL}{AE} = \Sigma \frac{PL}{AE}$
Stress concentration factor	$K = \frac{\sigma_{max}}{\sigma_{allow}}$
Angle of distortion	$\gamma = \frac{\pi}{2} - \theta'$
Angle of distortion	$\gamma = \left(\frac{\rho}{c}\right)\gamma_{max}$
Shear stress	$\tau = \left(\frac{\rho}{c}\right)\tau_{max}$
Shear stress	$\tau = \frac{T\rho}{J}$
Maximum shear stress	$\tau_{max} = \frac{Tc}{J}$
Polar moment of inertia (solid shaft)	$J = \frac{\pi}{2} c^4$
Polar moment of inertia (hollow shaft)	$J = \frac{\pi}{2}\left(c_0{}^4 - c_i{}^4\right)$
Torque (T')	$T' = \frac{2\pi\tau_{max}}{c} \int_{c/2}^{c} \rho^3 d\rho$
Power	$P = T\frac{d\theta}{dt} = T\omega$
Power	$P = 2\pi fT$
Allowable shear stress	$\tau_{allow} = \frac{Tc}{J}$
Angle of twist	$\phi = \int_0^L \frac{T(x)dx}{J(x)G} = \frac{TL}{JG} = \Sigma \frac{TL}{JG}$
Displacement of a point on an arc	$S = \phi \cdot r$

STRESS CONCENTRATION FACTOR (K) CHARTS