UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/2009
Peperiksaan Semester Pertama
Sidang Akademik 2008/2009

November 2008
November 2008

EMM 221/3 – Strength of Materials
Kekuatan Bahan

Duration : 3 hours
Masa : 3 jam

INSTRUCTIONS TO CANDIDATE:
ARAHAN KEPADA CALON :

Please check that this paper contains **SEVEN (7)** printed pages, **ONE (1)** page appendix and **SIX (6)** questions before you begin the examination.
*Sila pastikan bahawa kertas soalan ini mengandungi **TUJUH (7)** mukasurat bercetak, **SATU (1)** mukasurat lampiran dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan.*

Answer **FIVE (5)** questions.
*Jawab **LIMA (5)** soalan.*

Answer all questions in **ENGLISH** OR **BAHASA MALAYSIA** OR a combination of both.
*Calon boleh menjawab semua soalan dalam **BAHASA MALAYSIA** ATAU **BAHASA INGGERIS** ATAU kombinasi kedua-duanya.*

Each question must begin from a new page.
Setiap soalan mestilah dimulakan pada mukasurat yang baru.

Appendix/*Lampiran*:

1. Table of Average Mechanical Properties of Typical Engineering Materials (SI Units)
[1 page/*mukasurat*]

Q1. The 50 mm diameter cylinder is made of Am 1004-T61 magnesium and is placed in the clamp when the temperature is $T_1 = 30^\circ C$ as shown in the Figure Q1. The two 304 stainless steel carriage bolts of the clamp each have a diameter of 10 mm with 20 threads per 20 mm, and they hold the cylinder snug with negligible force against the rigid jaws. In answering the followings, the explanation of whether it is statically determinate problem, the equations of equilibrium and compatibility, the free body diagram and the geometry (diagram) of deformation must be included.

Satu silinder magnesium Am 1004-T61 berdiameter 50 mm diletakkan antara pengapit pada suhu $T_1 = 30^\circ C$ seperti dalam Rajah S1. Dua bolt pembawa keluli tahan karat 304 pada pengapit, masing-masing berdiameter 10 mm dengan 20 lilitan per 20 mm, dan mereka memegang sendat silinder dimana daya bertindak pada rahang-rahang tegar boleh diabaikan. Semasa menjawab soalan berikut, penerangan sama ada ini masalah penentuan secara statik, persamaan-persamaan keseimbangan dan keserasian, rajah jasad bebas serta ubah bentuk geometri (rajah) perlu disertakan.

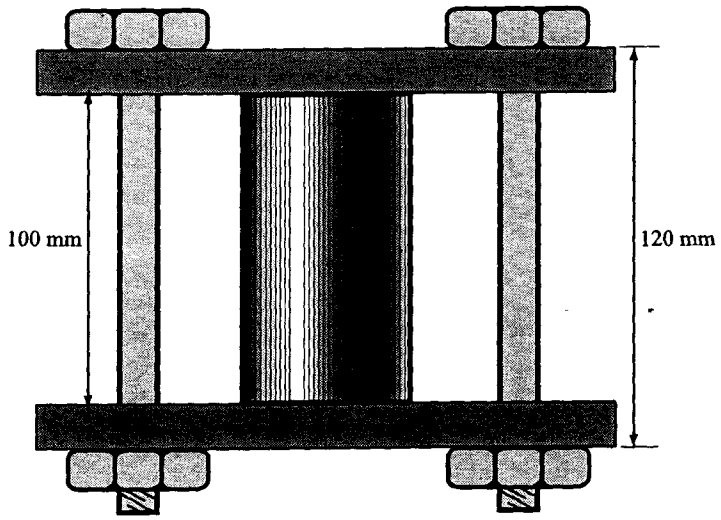

Figure Q1
Rajah S1

[a] Using a wrench, each nut is further tightened one full turn. Determine the stresses in bolt and cylinder, and explain whether this "elastic" analysis is valid or not.

Menggunakan perungkah, setiap nat diketatkan lagi sebanyak satu pusingan. Tentukan tegasan pada bolt dan silinder, serta terangkan sama ada analisis "elastik" ini adalah sah atau tidak.

(70 marks/*markah*)

[b] **Then, if the temperature is decreased to $T_2 = 10^{\circ}C$, determine the stresses in bolt and cylinder.**

Selepas itu, jika suhu dikurangkan kepada $T_2 = 10^{\circ}C$, tentukan tegasan pada bolt dan silinder.

(30 marks/*markah*)

Q2. **The cantilever beam is subjected to the distributed loading and moment M_0 shown in Figure Q2.**

Rasuk julur dikenakan beban teragih dan momen M_0 seperti yang ditunjukkan dalam Rajah S2.

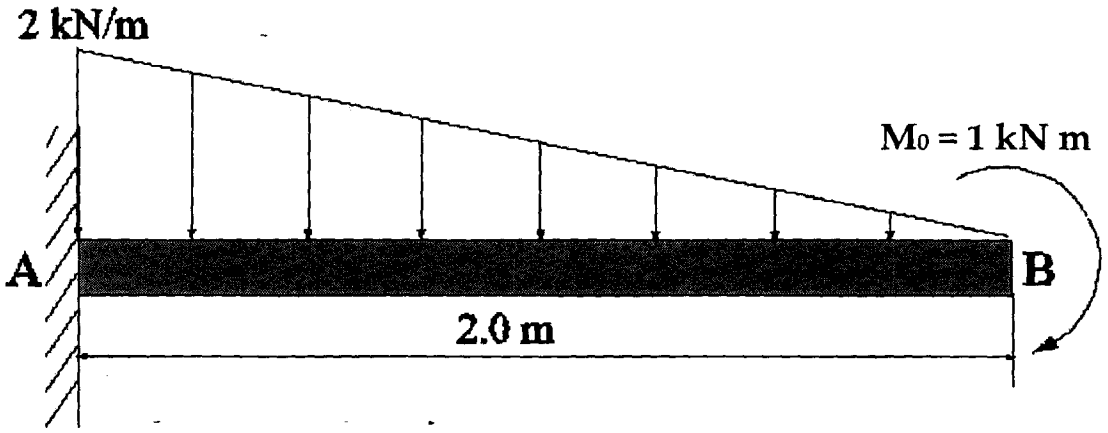

Figure Q2
Rajah S2

(i) **Determine the shear force, F and bending moment, M throughout the beam as functions of x.**

Tentukan daya ricih, F dan momen lentur, M sebagai fungsi x bagi rasuk tersebut.

(70 marks/*markah*)

(ii) **Draw the shear force and bending moment diagrams.**

Lukiskan rajah daya ricih dan rajah momen lentur.

(30 marks/*markah*)

Q3. **The beam in Figure Q3 is fixed at A and simply supported at B. If it is subjected to the distributed load p, determine the slope and deflection of the beam in term of x, *l*, p, E and I. Modulus of elasticity and moment of inertia of the beam are E and I, respectively.**

Rasuk dalam Rajah S3 ditetapkan pada A dan disokong mudah pada B. Jika ia dikenakan beban teragih p, tentukan kecerunan dan pesongan bagi rasuk tersebut dalam sebutan x, l, p, E dan I. Modulus elastik dan momen inersia bagi rasuk, masing-masing adalah E dan I.

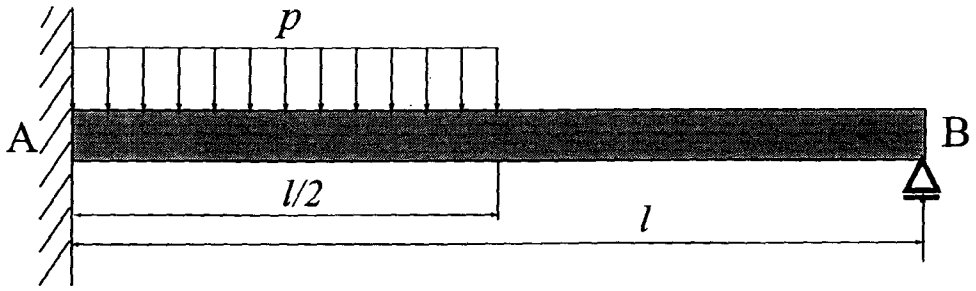

Figure Q3
Rajah S3

(100 marks/*markah*)

Q4. **[a]** **Define the following terms and cite *an example for each case* together with a sketch showing the condition reflecting such case**

(i) Plane stress
(ii) Plane strain
(iii) Principal plane

Berikan definisi istilah berikut dan nyatakan satu contoh bagi setiap kes dengan lakaran yang menggambarkan contoh tersebut

(i) Tegasan satah
(ii) Terikan satah
(iii) Satah utama

(40 marks/*markah*)

[b] **For the loading condition shown in the components below calculate the principal stresses and the maximum shear stress at the point and draw the Mohr's circle representing the stress condition in each point**

Bagi keadaan tegasan yang ditunjukkan di dalam unsur-unsur di bawah, kirakan tegasan utama dan tegasan riceh utama dan lakarkan Bulatan Mohr yang mewakili keadaan tegasan bagi setiap unsur.

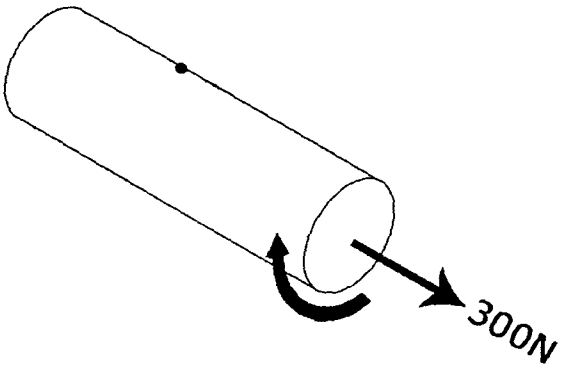

Figure Q4[b]
Rajah S4[b]

(60 marks/*markah*)

Q5. **A gear driven pump is shown in Figure Q5. The pump impeller is represented as A and supported by deep groove ball bearings at B and C. The gear is transmitting power from the motor to the shaft of the pump. Assuming that the force from the contact at the gear teeth can be represented by the following force vector :**

$$\underline{F} = 700\,\underline{i} - 700\,\underline{j}\ \text{N}$$

And the position vector of the contact point to the centre line of the shaft is given as

$$\underline{r} = 250\,\underline{j}\ \text{mm}$$

The bearings are assumed to absorb all the radial load and the pump impeller is absorbing all the supplied torque.
Determine the minimum radius of a solid shaft suitable for this case when the allowable normal stress is 100 MPa and the allowable shear stress is limited to 60 MPa.

Sebuah pam yang dipacu menggunakan gear ditunjukkan di dalam Rajah S5. Pendesak pam di wakili oleh A dan disokong oleh galas bebola di B dan C. Gear tersebut menghantar kuasa daripada motor kepada syaf pam. Andaikan daya yang bertindak pada titik sentuh boleh diwakili oleh vektor daya berikut:

$$\underline{F} = 700\,\underline{i} - 700\,\underline{j}\ N$$

Dan vektor kedudukan titik sentuh diukur daripada garis paksi syaf diberikan oleh vektor berikut :

$$\underline{r} = 250\,\underline{j}\ mm$$

Galas bebola dianggap menanggung kesemua bebaban jejarian dan pendesak pam menyerap kesemua kilas yang dihantar oleh syaf.
Tentukan jejari minimum bagi syaf padu jika tegasan normal yang dibenarkan ialah 100 MPa dan tegasan riceh yang dibenarkan ialah 60 MPa.

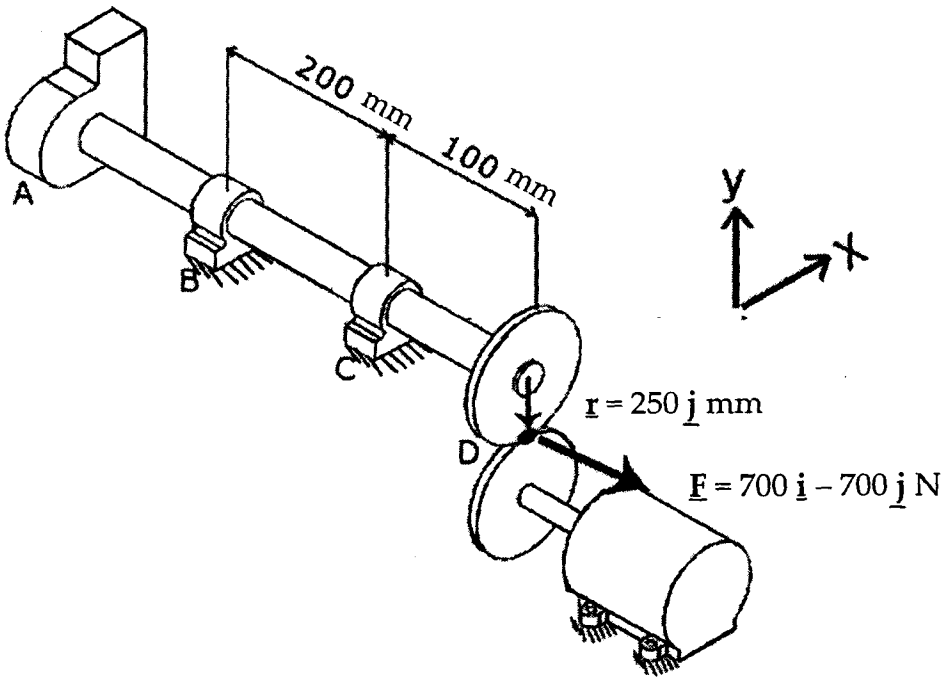

Figure Q5
Rajah S5

(100 marks/*markah*)

Q6. [a] **For an assembly of a shaft and a disc, the shaft is required to fit into a disc of an outer diameter of 250 mm and inner diameter of 50 mm with thickness of 25 mm. The shaft is solid steel and the disc is also made of steel (E = 200 GPa, ν = 0.28). Determine the following:**

(i) The normal stress at the interface

(ii) The hoop stress at the interface for the disc.

(iii) The normal force at the interface

(iv) The force needed to overcome friction to push the shaft into the disc if the friction coefficient at the interface is 0.4

(v) The maximum torque that can be transmitted through the disc-shaft assembly based on the friction at the interface only

Bagi satu pepasang syaf dan cakera di mana syaf di pasang ketat kepada cakera yang mempunyi diameter luaran 250 mm dan diameter dalaman 50 mm dengan ketebalam 25 mm. Syaf padu tersebut di buat daripada keluli (E = 200 GPa, ν = 0.28). Tentukan yang berikut:

(i) Tegasan normal pada antaramuka

(ii) Tegasan lingkar pada antaramuka untuk cakera

(iii) Daya normal pada antaramuka

(iv) Daya yang diperlukan untuk mengatasi geseran apabila syaf ditolak masuk kedalam cakera jika pekali geseran di antara muka ialah 0.4

(v) Kilas maksimum yang boleh dihantar menerusi pepasang syaf-cakera tersebut berdasarkan geseran pada antaramuka sahaja

(80 marks/*markah*)

[b] **Assess suitability of the shaft-disc pair using interference fit to transmit torque when compared to the use of key and keyway as a mean of locating the disc to the shaft when transmitting torque.**

Berikan penilaian anda tentang kesesuaian pasangan syaf-cakera dengan pemasangan interferens bila dibandingkan dengan pemasangan menggunakan kekunci dan alur kekunci sebagai cara menetapkan cakera kepada syaf apabila menghantar kilas.

(20 marks/*markah*)

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LAMPIRAN 1

Average Mechanical Properties of Typical Engineering Materials (SI Units)

Materials		Density ρ (Mg/m^3)	Modulus of Elasticity E (GPa)	Modulus of Rigidity G (GPa)	Yield Strength (MPa)	Coef. of Therm. Expansion α (10^{-6})/°C
Metallic						
Aluminum Wrought Alloys	2014-T6	2.79	73.1	27	414	23
	6061-T6	2.71	68.9	26	255	24
Cost Iron Alloys	Gray ASTM 20	7.19	67.0	27		12
	Malleable ASTM A-197	7.28	1.72	68		12
Copper Alloys	Red Brass C83400	8.74	101	37	70.0	18
	Bronze C86100	8.83	103	38	345	17
Magnesium Alloy [Am 1004-T61]		1.83	44.7	18	152	26
Steel Alloys	Structural A36	7.85	200	75	400	12
	Stainless 304	7.86	193	75	517	17
	Tool L2	8.16	200	75	800	12
Titanium Alloy	[Ti-6A 1-4V]	4.43	120	44	1000	9.4
Nonmetallic						
Concrete	Low Strength	2.38	22.1	-	-	11
	High Strength	2.38	29.0	-	-	11
Plastic Reinforced	Kevlar 49	1.45	131	-	-	-
	30% Glass	1.45	72.4	-	-	-