
UNIVERSITI SAINS MALAYSIA

First Semester Examination
2014/2015 Academic Session

December 2014/January 2015

EEM 101 – PRINCIPLES AND MECHANICS OF MATERIALS
[PRINSIP DAN MEKANIK BAHAN]

Duration : 3 hours

[Masa : 3 jam]

Please check that this examination paper consists of **EIGHT (8)** pages and Appendix **TWELVE (12)** of printed material before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **LAPAN (8)** mukasurat dan Lampiran **DUA BELAS (12)** muka surat bercetak sebelum anda memulakan peperiksaan ini.]*

Instructions: This question paper consists of **SIX (6)** questions. Answer **FIVE (5)** questions. All questions carry the same marks.

Arahan: *Kertas soalan ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan. Semua soalan membawa jumlah markah yang sama.]*

Answer to any question must start on a new page.

[Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru]

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

1. (a) For a FCC unit cell, state

Bagi unit sel FCC, nyatakan

- i) Number of atoms in a unit cell and the coordination number for the atoms

Bilangan atom dalam unit sel and nombor koordinasi bagi atom

- ii) The relationship between the length of side, a of the FCC unit cell and the radius of its atom, R and finally derive the atomic packing factor (APF)

Hubungan antara panjang sisi, a bagi unit sel FCC and jejari atom, R dan akhirnya ungkapkan faktor pepadatan atom (APF)

(25 marks/markah)

- (b) A sample of BCC metal was placed in an X-ray diffractometer using X-rays with a wavelength of $\lambda = 0.541$ nm. Diffraction from the (2 2 1) plane was obtained at $2\theta = 88.838^\circ$. Calculate a value for the lattice constant, a for this BCC metal. Assume first-order diffraction, $n=1$.

Satu sampel logam BCC diletakkan dalam meter belauan sinar-X dengan menggunakan sinar-X dengan panjang gelombang, $\lambda = 0.541$ nm. Belauan dari satah (2 2 1) diperolehi pada $2\theta = 88.838^\circ$. Kirakan satu nilai untuk pemalar kelisi, a untuk logam BCC ini. Anggap bahawa belauan tertib pertama, $n=1$.

(20 marks/markah)

- (c) i) Discuss the mechanism of diffusion. State and define the Fick's first and second law.

Bincangkan mekanisma resapan. Nyatakan dan beri definisi hukum pertama dan kedua Fick.

(20 marks/markah)

- ii) Consider the gas carburizing of a gear of 1020 steel at 927°C. Assume that the carbon content at the surface is 0.90%, and the steel has a nominal carbon content of 0.20 %. Given that $D_{927^{\circ}\text{C}} = 1.28 \times 10^{-11} \text{ m}^2/\text{s}$.

Calculate the time in minutes necessary to increase the carbon content to 0.40% and 0.50 mm below the surface.

Pertimbangkan penyusukkarbonan gas bagi gear keluli 1020 pada suhu 927°C. Anggapkan bahawa kandungan karbon pada permukaan ialah 0.90%, dan keluli mempunyai kandungan nominal karbon pada 0.20%. Diberi bahawa $D_{927^{\circ}\text{C}} = 1.28 \times 10^{-11} \text{ m}^2/\text{s}$.

Kirakan masa dalam minit yang diperlukan untuk meningkatkan kandungan karbon kepada 0.40% dan 0.50 mm di bawah permukaan.

(35 marks/markah)

2. (a) Describe and illustrate edge and screw dislocations.
Terangkan dan gambarkan kehelan pinggir dan skru.

(25 marks/markah)

- (b) Consider a cylindrical specimen of a metal alloy that has a diameter of 8.0 mm. A tensile force of 1000 N produces an elastic reduction in diameter of $2.8 \times 10^{-4} \text{ mm}$. Compute the modulus of elasticity for this alloy, given that Poisson's ratio is 0.30.

Pertimbangkan spesimen silinder satu logam aloi dengan diameter 8.0 mm. Satu daya tegangan 1000 N menghasilkan pengurangan kekenyalan dalam diameter sebanyak $2.8 \times 10^{-4} \text{ mm}$. Kirakan modulus kekenyalan bagi aloi ini, diberi nisbah Poisson ialah 0.30.

(30 marks/markah)

- (c) A 70% Cu—30% Zn brass sheet is to be cold-drawn 20 percent to a diameter of 2.80 mm. It is then further cold-drawn to a diameter of 2.45 mm.

Sekeping loyang 70% Cu—30% Zn ditariksejukkan sebanyak 20% ke diameter 2.80 mm. Ia seterusnya ditariksejukkan lagi ke diameter 2.45 mm.

- i) Calculate the total percent cold-work that the wire undergoes
Kirakan jumlah kerja-sejuk yang dilalui oleh wayar tersebut.
- ii) Estimate the wire's tensile strength, yield strength in MPa and elongation from Figure 2(c)
Anggarkan kekuatan tegangan, kekuatan alah dalam MPa dan pemanjangan dari Rajah 2(c).
- iii) When a cold worked metal is further then heated into the temperature range where recrystallization takes place, explain on how are the following affected; internal residual stress, strength, ductility and hardness.

Apabila logam yang dikerjasejuk kemudiannya dipanaskan pada suhu di mana proses penghabluran semula, terangkan bagaimana yang berikut terkesan; tegasan baki dalaman, kekuatan, kemuluran dan kekerasan.

(45 marks/markah)

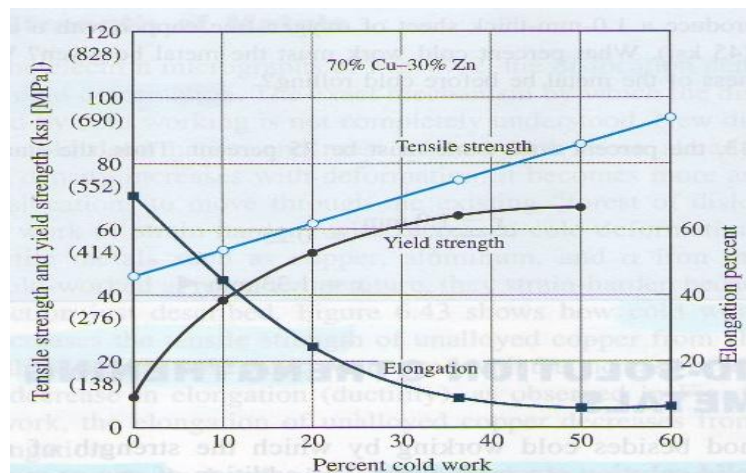


Figure 2(c)
Rajah 2(c)

3. (a) i) Explain what is ductile and brittle fracture. Compare both of it.

Terangkan maksud patah mulur dan patah rapuh. Bandingkan keduanya.

- ii) Define what is ductile-brittle transition temperature (DBTT). Describe briefly what one of the example related to DBTT.

Beri definisi suhu peralihan mulur-rapuh (DBTT). Terangkan secara ringkas satu contoh yang berkait dengan DBTT.

(30 marks/markah)

- (b) i) List out the mechanism to strengthen up single-phase metals.

Senaraikan mekanisme untuk menguatkan logam fasa-tunggal.

- ii) By using the aid of diagrams, explain each of the mechanism.

Dengan menggunakan bantuan rajah, terangkan setiap mekanisma.

(25 marks/markah)

- (c) A stress of 4.75 MPa is applied in the $[0\ 0\ \bar{1}]$ direction of a unit cell of an FCC copper single crystal. Calculate the resolved shear stress on the $[1\ 1\ \bar{1}]$ plane in the $[\bar{1}\ 0\ \bar{1}]$ direction.

Tegangan sebanyak 4.75 MPa dikenakan pada arah $[0\ 0\ \bar{1}]$ bagi satu unit sel kristal tunggal tembaga FCC. Kirakan tegangan ricih peleraian bagi satah $[1\ 1\ \bar{1}]$ dalam arah $[\bar{1}\ 0\ \bar{1}]$

(45 marks/markah)

4. (a) Derive the relationship between:

Terbitkan hubungan antara:

i) Torque and shear stress

Kilasan dan tegasan ricih

(25 marks/markah)

ii) torque and angle of twist

kilasan dan sudut kilasan.

(25 marks/markah)

(b) The pipe shown in figure 4 has an inner diameter of 80 mm and an outer diameter of 100 mm. If its end is tightened against the support at A using a torque wrench at B, determine the shear stress developed in the material at the inner and outer walls at C, the central portion of the pipe when the 80-N forces are applied to the wrench.

Sebatang paip yang ditunjukkan di dalam rajah 4 mempunyai garispusat dalaman 80 mm dan garispusat luaran 100 mm. Sekiranya hujung paip diketatkan pada penyokong pada A menggunakan sepana kilasan pada B, tentukan tegasan ricih yang terhasil pada dinding dalam dan dinding luar paip pada C, bahagian tengah paip apabila daya 80-N dikenakan pada sepana kilasan.

(50 marks/markah)

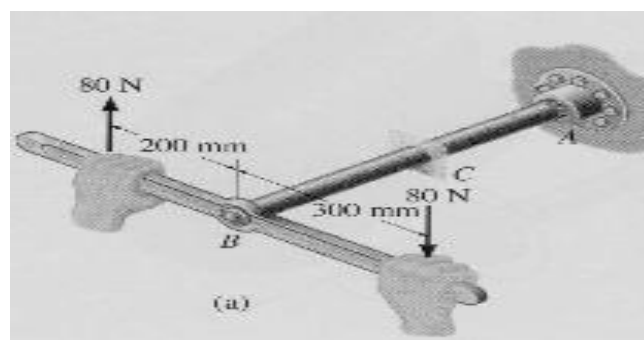


Figure 4
Rajah 4

5. (a) Explain the relationship between load, shear and moment. Draw suitable sketches.

Terangkan hubungan antara beban, ricih dan momen. Lukis lakaran yang sesuai.

(40 marks/markah)

- (b) The man has a mass of 78 kg and stands motionless at the end of the diving board. If the board has the cross section shown, determine the maximum normal strain developed in the board. The modulus of elasticity for the material is 125 GPa. Assume A is a pin and B is a roller.

Seorang lelaki mempunyai jisim 78 kg berdiri pegun diujung papan anjal. Sekiranya papan tersebut mempunyai keratan rentas seperti ditunjukkan, tentukan terikan normal maksima yang wujud dalam papan tersebut. Modulus kekenyalan bagi papan anjal ialah 125 GPa. Anggap A sebagai pin dan B sebagai guling.

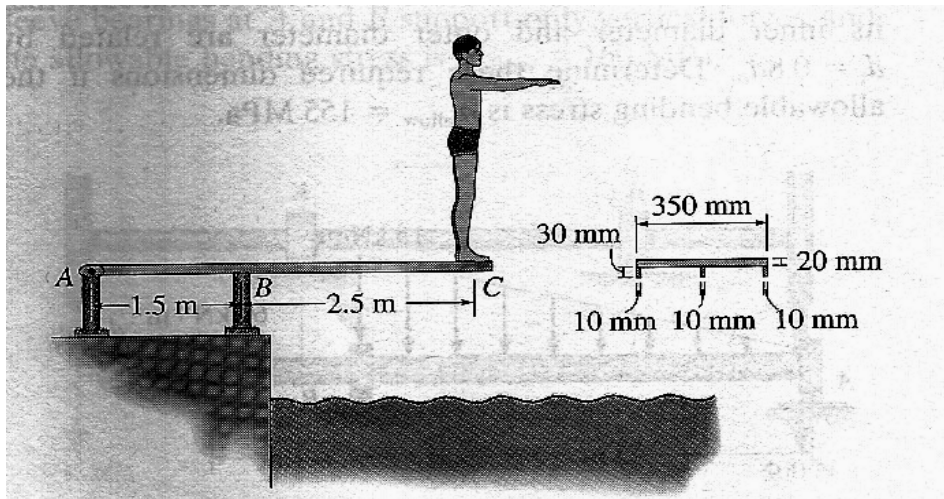


Figure 5(b)

Rajah 5(b)

(60 marks/markah)

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6. (a) A 150×360 rectangular Southern Pine section is used in a 3-m cantilever span. Compute the maximum deflection and the maximum slope due to a uniform load of 15 kN/m using:-

Kayu Southern Pine dengan 150×360 keratan rentas segiempat digunakan sebagai julur sepanjang 3 m. Kira lenturan maksima dan cerun maksima disebabkan beban seragam sebanyak 15 kN/m menggunakan:-

- i) Formula Method
Kaedah Formula

(20 marks/markah)

- ii) Moment Area Method
Kaedah Momen Luas

(50 marks/markah)

- (b) Describe the relationship between curvature and bending moment. Draw suitable sketches.

Terangkan hubungan antara lengkungan dan momen lenturan. Lukis lakaran yang sesuai.

(30 marks/markah)