UNIVERSITI SAINS MALAYSIA

First Semester Examination
2016/2017 Academic Session

December 2016 / January 2017

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 **THIRTEEN (13)** pages and Appendices **NINE (9)** pages of printed material before you begin the examination. This examination paper consist of two versions, The English version and Malay version. The English version from page **TWO (2)** to page **SEVEN (7**) and Malay version from page **EIGHT (8)** to page **THIRTEEN (13).**

*Sila pastikan bahawa kertas peperiksaan ini mengandungi **TIGA BELAS (13)** muka surat dan Lampiran **SEMBILAN (9)** muka surat bercetak sebelum anda memulakan peperiksaan ini. Kertas peperiksaan ini mengandungi dua versi, versi Bahasa Inggeris dan Bahasa Melayu. Versi Bahasa Inggeris daripada muka surat **DUA (2)** sehingga muka surat **TUJUH (7**) dan versi Bahasa Melayu daripada muka surat **LAPAN (8)** sehingga muka surat **TIGA BELAS (13)**.*

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

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

Begin your answer to each question 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 diguna pakai]

ENGLISH VERSION

1. (a) For a Body Centered Cubic (BCC) unit cell, sketch the reduced sphere unit cell and determine

(i) Number of atoms inside the unit cell.
(ii) The coordination number for the atoms.
(iii) The relationship between the lattice constant, *a* and the radius of its atom, *r.*
(iv) Verify that the atomic packing factor of BCC is 0.68.

(30 marks)

(b) Calculate the planar density on the (1 1 0) plane of the α iron BCC lattice in atoms per square millimeter. The lattice constant of α iron is 0.287 nm.

(30 marks)

(c) Pure iron goes through a polymorphic change from Body Centered Cell (BCC) to Face Centered Cell (FCC) upon heating through 912^{o}C. Given that the BCC lattice constant, a = 0.293 nm and the FCC unit cell, a = 0.363 nm.

(i) Calculate the percentage of volume change (in terms of volume per atom number) associated with the change of the crystal structure.

(ii) Describe briefly what are the effect of the changes in crystal structure.

(40 marks)

2. (a) (i) State the Fick's first and second laws in equation form and define all parameters.

(10 marks)

(ii) Compare interstitial and vacancy atomic mechanisms for difussion.

(15 marks)

(b) A steel gear made of 1018 steel (0.18 wt% C) is to be gas-carburized at 927^{O}C. If the carburizing time is 7.5 hours, at what depth in millimeters will the carbon content be 0.040 wt%?

Assume the carbon content at the surface of the gear is 1.20 wt%. Given that the diffusion coefficient , D (C in iron) at 927^{O}C = 1.28 X 10^{-11} m^2/s.

(35 marks)

(c) A cylindrical rod of copper (E = 110 GPa) having a yield strength of 240 MPa is to be subjected to a load of 6660 N. If the length of the rod is 380 mm, what must be the diameter to allow an elongation of 0.50 mm?

(40 marks)

3. (a) A brass wire is coldworked 30% to a diameter of 0.90 mm. It is then further cold-worked to 0.70 mm. What is the total percent of cold work reduction?

(35 marks)

(b) Consider a single crystal of silver oriented such that a tensile stress is applied along a [001] direction. If slip occurs on a (111) plane and in a direction, and is initiated at an applied tensile stress of 1.4 MPa, compute the critical resolved shear stress.

(35 marks)

(c) (i) Explain briefly the differences between ductile and brittle fracture.

(15 marks)

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

(15 marks)

4. (a) Explain the importance of knowing the shear force and bending moment diagram.

(20 marks)

(b) A man with a mass of 78 kg is standing still at the end of a diving board as shown in Figure 4(b). The modulus of elasticity for the material is 125 GPa. Assume A is a pin and B is a roller.

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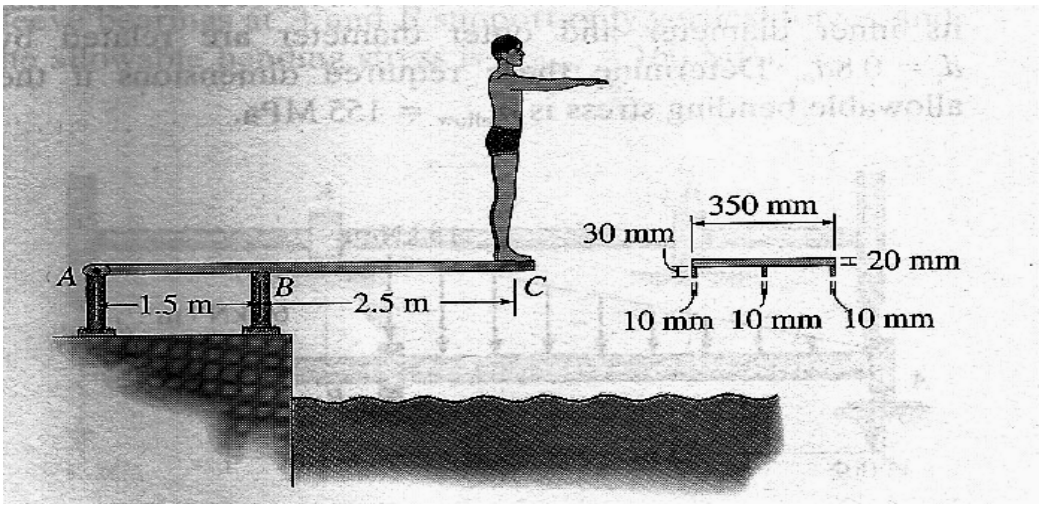

Figure 4(b)

(i) Calculate the reaction forces at A and B (20 marks)

(ii) Draw the shear force and bending moment diagrams for the diving board (40 marks)

(iii) Calculate the maximum shear stress in the diving board (20 marks)

5. (a) A reinforced concrete beam has the cross-section as shown in Figure 5(a) Determine the allowable moment for the beam. Given:

$$n = E_{st} / E_{cn} = 8 \quad (1)$$

$$(\sigma_{st})_{allow} = 20\ 000\ \text{psi} \quad (2)$$

$$(\sigma_{st})_{allow} = 1\ 800\ \text{psi} \quad (3)$$

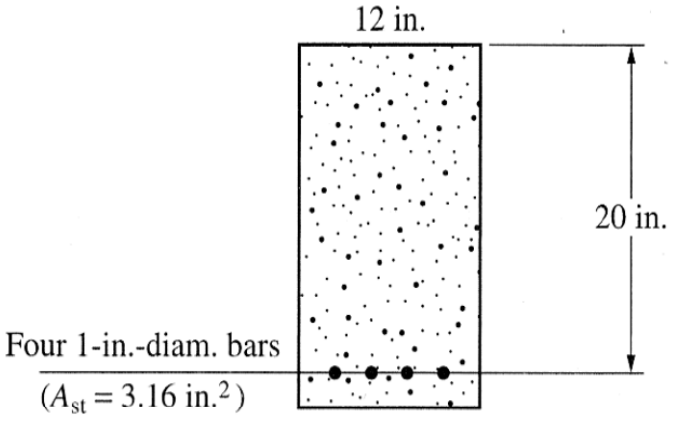

Figure 5(a)

(70 marks)

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

(30 marks)

6. (a) Derive the relationship between:

(i) Torque and shear stress (25 marks)

(ii) Torque and angle of twist (25 marks)

(b) The pipe shown in Figure 6(b) has an inner diameter of 80 mm and an outer diameter of 100 mm. Its end is tightened against the support at A using a torque wrench at B.

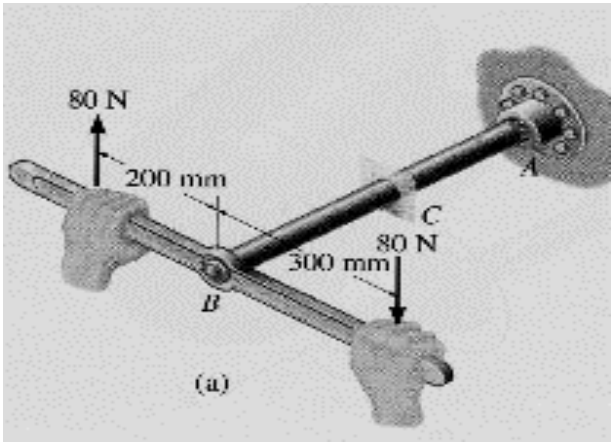

Figure 6(b)

(i) Determine the shear stress developed in the pipe at the inner and outer walls, when the 80-N forces are applied to the wrench.

(30 marks)

(ii) Discuss the suitability of the pipe made of:

(1) Material A, Yield Strength = 100 MPa, Density = 2.7 g/cm^3
(2) Material B, Yield Strength = 25 MPa, Density = 1 g/cm^3

(20 marks)

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VERSI BAHASA MELAYU

1. (a) Bagi unit sel unit berpusat jasad (BCC), lakarkan unit sel sfera terturun dan tentukan:

(i) Bilangan atom di dalam unit sel
(ii) Bilangan nombor koordinasi bagi atom-atom
(iii) Hubungkait antara pemalar kekisi, *a* dan jejari atom, *r*
(iv) Tentusahkan bahawa faktor pemadatan atom bagi BCC ialah 0.68

(30 markah)

(b) Kira kepadatan planar bagi satah (1 1 0) kekisi BCC besi *α* dalam atom per mililmeter persegi. Pemalar kekisi bagi besi *α* ialah 0. 287 nm.

(30 markah)

(c) Iron tulen melalui perubahan polimorfik dari unit sel berpusat jasad, BCC ke unit sel berpusat muka, FCC melalui pemanasan pada suhu 912^{O}C. Diberi pemalar kekisi unit sel BCC ialah, *a* = 0.293 nm dan pemalar kekisi unit sel FCC ialah , *a* = 0.363 nm.

(i) Kira peratus perubahan isipadu (dalam bentuk isipadu per bilangan atom) yang berkait dengan perubahan struktur kristal tersebut.
(ii) Terangkan secara ringkas kesan dari perubahan struktur kristal tersebut.

(40 markah)

2. (a) (i) Nyatakan hukum pertama dan kedua Fick dan beri definisi bagi kesemua parameter.

(10 markah)

(ii) Bandingkan mekanisma resapan celahan dan kekosongan atom

(15 markah)

(b) Suatu gear keluli diperbuat dari keluli 1018 (0.18 et% C) akan digas-mengkarbon pada $927^{O}C$. Jika masa mengkarbon ialah 7.5 jam, pada kedalaman apa dalam milimeter kandungan karbon akan menjadi 0.040 wt%?

Anggapkan kandungan karbon pada permukaan gear ialah 1.20 wt%. Diberi pekali resapan, D (C dalam iron) pada $927^{O}C = 1.28 \times 10^{-11}$ m^2/s.

(35 markah)

(c) Suatu rod silinder tembaga (E = 110 GPa) mempunyai kekuatan alah sebanyak 240 MPa diberikan beban 6660 N. Jika panjang rod tersebut ialah 380 mm, berapakah diameter yang diperlukan bagi pemanjangan 0.50 mm.

(40 markah)

3. (a) Suatu wayar loyang dikerjasejukkan 30% ke diameter 0.90 mm. Ia kemudian dikerjasejukkan lagi ke 0.70 mm. Berapakah jumlah peratus penurunan kerja sejuk?

(35 markah)

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(b) Pertimbangkan suatu kristal tunggal perak diorientasikan agar tegasan tegangan dikenakan sepanjang arah [001]. Jika gelincir terjadi pada satah (1 1 1) dan pada arah , dan digerakkan pada tegasan tegangan sebanyak 1.4 MPa, kirakan tegangan kritikal ricih peleraian.

(35 markah)

(c) (i) Terangkan secara ringkas perbezaan antara patah mulur dan patah rapuh.

(15 markah)

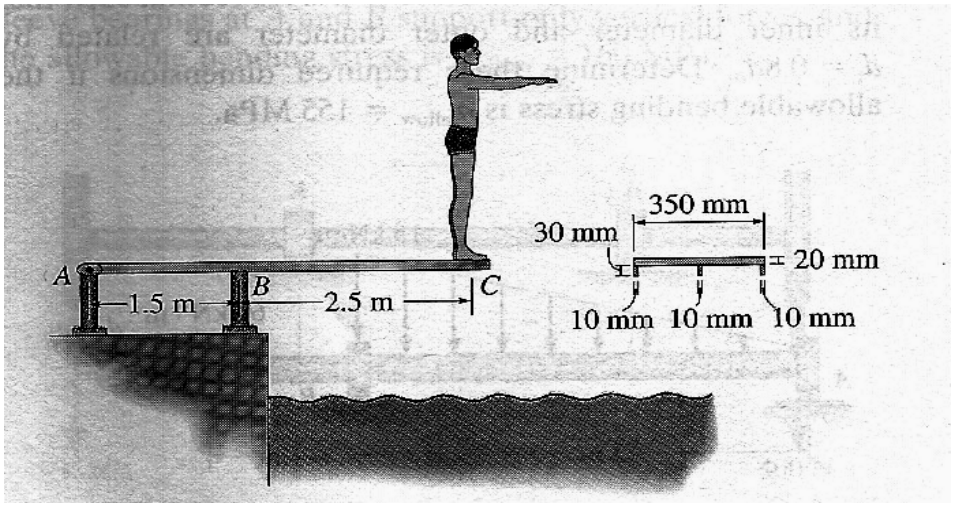
(ii) Beri definisi suhu peralihan mulur-rapuh, DBTT. Terangkan secara ringkas satu kes yang bekait dgn DBTT.

(15 markah)

4. (a) Terangkan kepentingan mengetahui gambarajah daya ricih dan momen lenturan

(20 markah)

(b) Seorang lelaki yang mempunyai jisim 78 kg berdiri pegun di hujung papan anjal ditunjukkan oleh Rajah 4(b) Modulus keanjalan bagi bahan papan anjal ialah 125 GPa. Anggap A sebagai pin dan B sebagai guling.



Rajah 4(b)

(i) Kira daya tindakbalas pada A dan B. (20 markah)

(ii) Lukis gambarajah daya ricih dan momen lenturan bagi papan anjal (40 markah)

(iii) Kira tegasan ricih maksima pada papan anjal (20 markah)

5. (a) Satu rasuk konkrit bertetulang mempunyai keratan rentas seperti ditunjukkan di dalam Rajah 5(a) Tentukan momen dibenarkan yang boleh ditanggung oleh rasuk. Diberikan:

$$n = E_{st} / E_{cn} = 8 \qquad (1)$$

$$(\sigma_{st})_{allow} = 20\ 000\ \text{psi} \qquad (2)$$

$$(\sigma_{st})_{allow} = 1\ 800\ \text{psi} \qquad (3)$$

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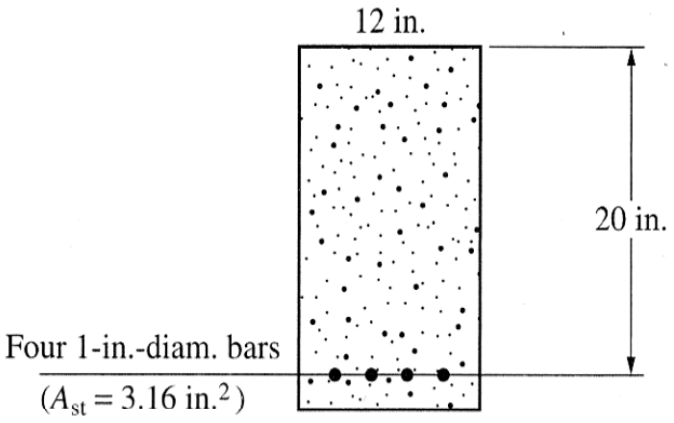

Rajah 5(a)

(70 markah)

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

(30 markah)

6. (a) Terbitkan hubungan antara:

(i) Kilasan dan tegasan ricih. (25 markah)

(ii) kilasan dan sudut kilasan. (25 markah)

(b) Sebatang paip yang ditunjukkan di dalam Rajah 6(b) mempunyai garispusat dalaman 80 mm dan garispusat luaran 100 mm. Hujung paip diketatkan pada penyokong pada A menggunakan sepana kilasan pada B.

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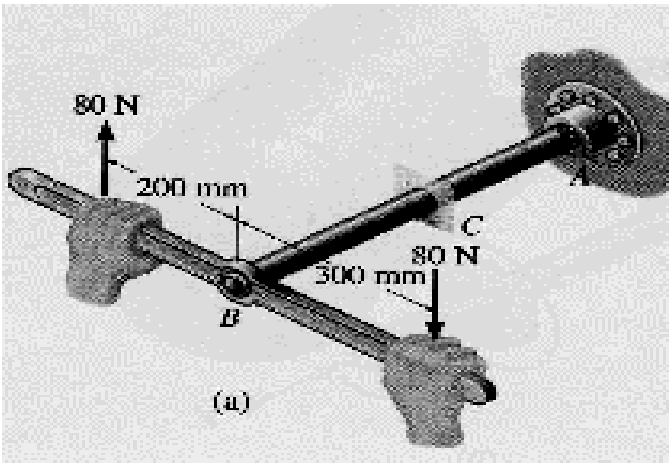

Rajah 6(b)

(i) Tentukan tegasan ricih yang terbina di dalam paip pada dinding dalaman dan luaran pada C, apabila daya-daya 80-N diberikan pada spana kilasan.
(30 markah)

(ii) Bincangkan kesesuaian bagi paip yang diperbuat daripada:

(1) Bahan A, Kekuatan alah = 100 MPa, Ketumpatan = 2.7 g/cm^3

(2) Bahan B, , Kekuatan alah = 25 MPa, Ketumpatan = 1 g/cm^3

(20 markah)

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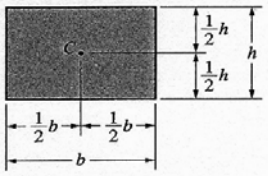
APPENDIX
LAMPIRAN

[EEM 101]

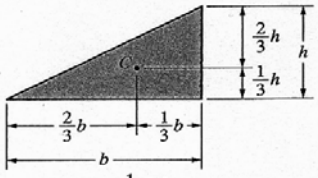
Centroids of Areas of Common Shapes

Rectangle



$A = bh$

Triangle

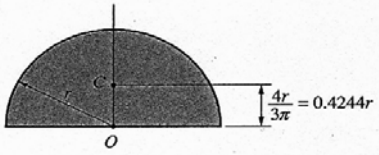


$A = \frac{1}{2}bh$

Circle

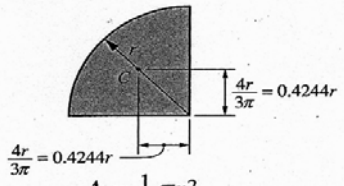
$A = \pi r^2$

Semicircle



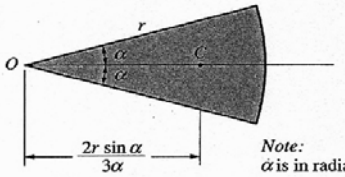
$A = \frac{1}{2}\pi r^2$

Quarter-Circle



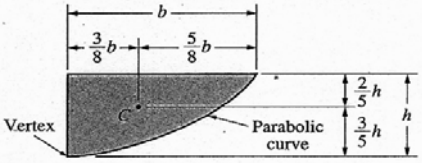
$A = \frac{1}{4}\pi r^2$

Sectors



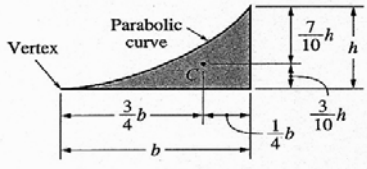
$A = \alpha r^2$

Semiparabolic Area



$A = \frac{2}{3}bh$

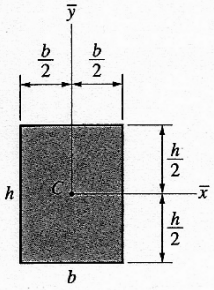
Parabolic Spandrel



$A = \frac{1}{3}bh$

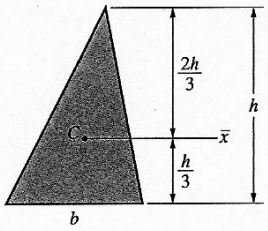
Properties of Areas of Common Shapes

Rectangle



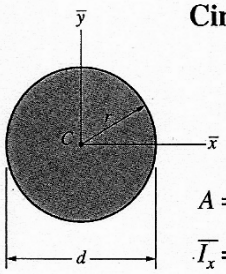
$$A = bh$$
$$\bar{I}_x = \frac{1}{12}bh^3$$
$$\bar{I}_y = \frac{1}{12}hb^3$$
$$\bar{J} = \frac{1}{12}bh(h^2 + b^2)$$
$$\bar{r}_x = \frac{h}{\sqrt{12}}$$
$$\bar{r}_y = \frac{b}{\sqrt{12}}$$

Triangle



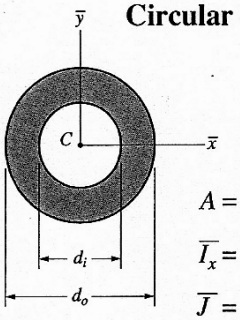
$$A = \frac{1}{2}bh$$
$$\bar{I}_x = \frac{1}{36}bh^3$$
$$\bar{r}_x = \frac{h}{\sqrt{18}}$$

Circle



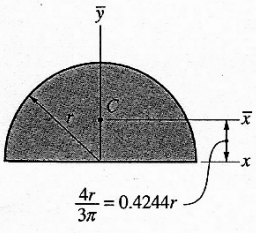
$$A = \frac{1}{4}\pi d^2 = \pi r^2$$
$$\bar{I}_x = \bar{I}_y = \frac{1}{64}\pi d^4 = \frac{1}{4}\pi r^4$$
$$\bar{J} = \frac{1}{32}\pi d^4 = \frac{1}{2}\pi r^4$$
$$\bar{r}_x = \bar{r}_y = \frac{1}{4}d$$

Circular Ring



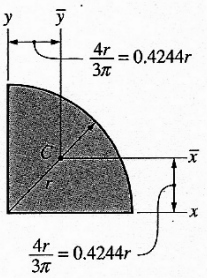
$$A = \frac{1}{4}\pi(d_o^2 - d_i^2)$$
$$\bar{I}_x = \bar{I}_y = \frac{1}{64}\pi(d_o^4 - d_i^4)$$
$$\bar{J} = \frac{1}{32}\pi(d_o^4 - d_i^4)$$
$$\bar{r}_x = \bar{r}_y = \frac{1}{4}\sqrt{d_o^2 + d_i^2}$$

Semicircle



$$A = \frac{1}{2}\pi r^2$$
$$\bar{I}_x = 0.1098r^4$$
$$\bar{I}_y = \bar{I}_x = \frac{1}{8}\pi r^4$$
$$\bar{J} = 0.5025r^4$$
$$\bar{r}_x = 0.2644r$$
$$\bar{r}_y = r_x = \frac{1}{2}r$$

Quarter-Circle



$$A = \frac{1}{4}\pi r^2$$
$$\bar{I}_x = \bar{I}_y = 0.0549r^4$$
$$I_x = I_y = \frac{1}{16}\pi r^4$$
$$\bar{J} = 0.1098r^4$$
$$\bar{r}_x = \bar{r}_y = 0.2644r$$
$$r_x = r_y = \frac{1}{2}r$$

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