The University of Nottingham

DEPARTMENT OF MECHANICAL, MATERIALS AND MANUFACTURING ENGINEERING

A LEVEL 2 MODULE, AUTUMN SEMESTER IN-CLASS TEST 2019-2020

MECHANICS OF SOLIDS

Time allowed FORTY minutes

Candidates may complete the front cover of their answer book and sign their desk card but must NOT write anything else until the start of the examination period is announced

Answer ALL questions

This examination consists of multiple-choice questions for which you should use the choice response sheet.

Only a calculator from approved list A (or one functionally equivalent) may be used in this examination.

Basic Models	***Scientific Calculators***
Aurora HC133	Aurora AX-582
Casio HS-5D	Casio FX82 family
Deli – DL1654	Casio FX83 family
Sharp EL-233	Casio FX85 family
	Casio FX350 family
	Casio FX570 family
	Casio FX 991 family
	Sharp EL-531 family
	Texas Instruments TI-30 family
	Texas BA II+ family

Dictionaries are not allowed with one exception. Those whose first language is not English may use a standard translation dictionary to translate between that language and English provided that neither language is the subject of this examination. Subject specific translation dictionaries are not permitted.

No electronic devices capable of storing and retrieving text, including electronic dictionaries, may be used.

DO NOT turn examination paper over until instructed to do so

ADDITIONAL MATERIAL: Multiple choice answer sheet
Formula sheet

INFORMATION FOR INVIGILATORS:
Question papers should be collected in at the end of the exam – do not allow candidates to take copies from the exam room.

INSTRUCTIONS

On the multiple-choice response sheet (in the boxes provided);

(a) Write your name in BLOCK LETTERS,
(b) Write the title and the module code of the paper in the box provided,
(c) Write your student ID number in the box supplied (top right-hand corner of the form) and IN CODED FORM in the space provided below it.

You MUST use a HB pencil to complete the multiple-choice response sheet. Mark your answer with a single horizontal line. To cancel a mark, you should rub it out carefully. You MUST NOT mark the response sheet in any other way. Unnecessary marks, creases or folds could result in the rejection of your response sheet by the computer.

You are offered FIVE possible answers to each question (A, B, C, D, E). ONLY ONE is correct in each case. If you do not know the answer you may choose not to guess.

A correct answer will be rewarded with one mark. Both an abstention or an incorrect answer will receive a mark of zero. THERE IS NO NEGATIVE MARKING.

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Answer ALL questions
All questions are worth one mark

1. Fig. Q1 illustrates which type of material behaviour?

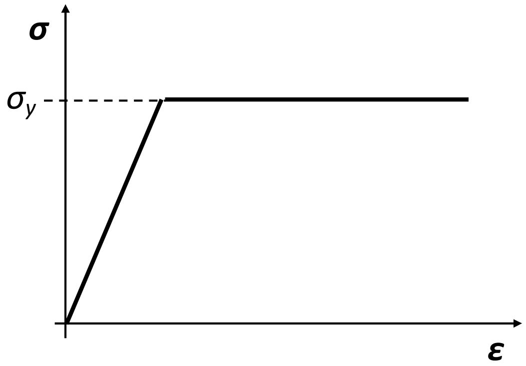


Fig. Q1

A. elastic-perfectly-plastic
B. linear softening
C. non-linear hardening
D. linear hardening
E. non-linear elasticity

2. Which stress component is important in determining yield according to the von Mises and Tresca yield criteria?

A. Hydrostatic stress
B. Deviatoric stress
C. Direct stress
D. Principal stress
E. Shear stress

3. A hollow shaft with an OD of 35 mm and a wall thickness of 2.5 mm will carry a torque of 400 Nm and an axial load of 20 kN. What is the maximum principal stress on a 2D plane stress element on the surface of the shaft?

A. -71.2 MPa
B. -32.0 MPa
C. 110.4 MPa
D. 149.6 MPa
E. 181.6 MPa

4. Fig. Q4 shows a beam which is simply supported at positions A and D and has an applied point moment, M_B, and an applied point load, P_C, at positions B and C, respectively. Using Macauley's method and taking the origin at position A of the beam, which of the following expresses the 2nd order differential equation for this beam?

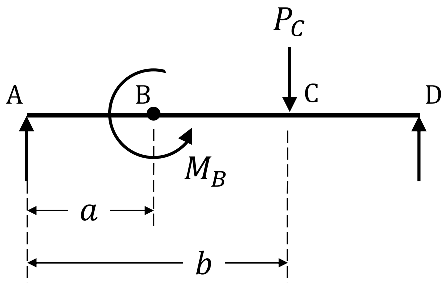


Fig. Q4

A. $EI\frac{d^2y}{dx^2} = R_Ax - M_B\langle x-a\rangle - P_C\langle x-b\rangle$

B. $EI\frac{d^2y}{dx^2} = R_Ax - M_B\langle x-a\rangle^0 - P_C\langle x-b\rangle$

C. $EI\frac{d^2y}{dx^2} = -M_B\langle x-a\rangle^0 - P_C\langle x-b\rangle$

D. $EI\frac{d^2y}{dx^2} = R_Ax + M_B\langle x-a\rangle^0 - P_C\langle x-b\rangle$

E. $EI\frac{d^2y}{dx^2} = -M_B\frac{\langle x-a\rangle^2}{2} - P_C\langle x-b\rangle$

5. What is the corresponding expression for deflection in the beam in Fig. Q4?

A. $y = \frac{1}{EI}\left(\frac{R_Ax^3}{6} - \frac{M_B\langle x-a\rangle^2}{2} - \frac{P_C\langle x-b\rangle^3}{6} + Ax + B\right)$

B. $\frac{dy}{dx} = \frac{1}{EI}\left(\frac{R_Ax^2}{2} - M_B\langle x-a\rangle - \frac{P_C\langle x-b\rangle^2}{2} + A\right)$

C. $y = \frac{1}{EI}\left(\frac{R_Ax^3}{6} - \frac{M_B\langle x-a\rangle^3}{6} - \frac{P_C\langle x-b\rangle^3}{6} + Ax + B\right)$

D. $EI\frac{dy}{dx} = \frac{R_Ax^2}{2} - \frac{M_B\langle x-a\rangle^2}{2} - \frac{P_C\langle x-b\rangle^2}{2} + A$

E. $y = \frac{1}{EI}\left(\frac{R_Ax^3}{6} + \frac{M_B\langle x-a\rangle^3}{6} - \frac{P_C\langle x-b\rangle^3}{6} + A\right)$

6. The hydrostatic stress component in Fig. Q6 is indicated by:

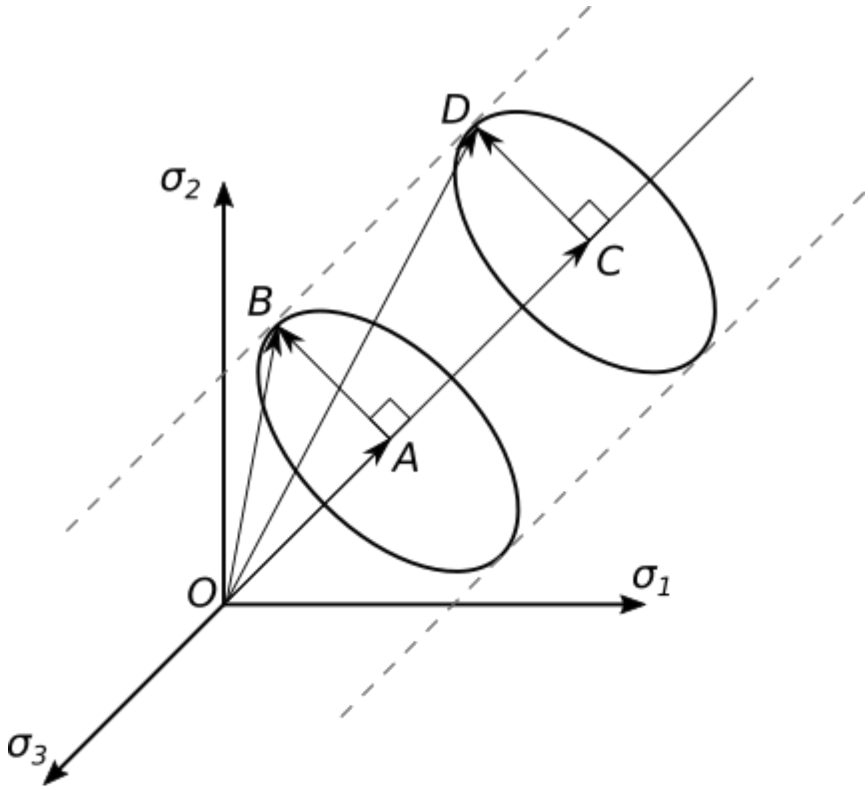


Fig. Q6

A. OA
B. OB
C. AB
D. AC
E. CD

7. An aluminium cylinder (15 mm bore and 17 mm outside diameter) is to be shrunk fit on the outside of a steel cylinder (12 mm bore and 15.015 mm outside diameter). What is the minimum temperature increase required for the aluminium cylinder to allow it to be placed around the steel cylinder?
($\alpha_{steel} = 12 \times 10^{-6}\ °C^{-1}$, $\alpha_{alu} = 23 \times 10^{-6}\ °C^{-1}$)

A. 10.1 °C
B. 38.4 °C
C. 43.5 °C
D. 73.5 °C
E. 83.2 °C

8. The compound bar assembly shown in Fig. Q8 is subjected to a temperature change of 40 °C. What will the stress in the steel bar be if both bars have a cross sectional area of 100 mm^2?
($\alpha_{steel} = 11 \times 10^{-6}\,°C^{-1}$, $E_{steel} = 200\ GPa$, $\alpha_{alu} = 23 \times 10^{-6}\,°C^{-1}$, $E_{alu} = 70\ GPa$)

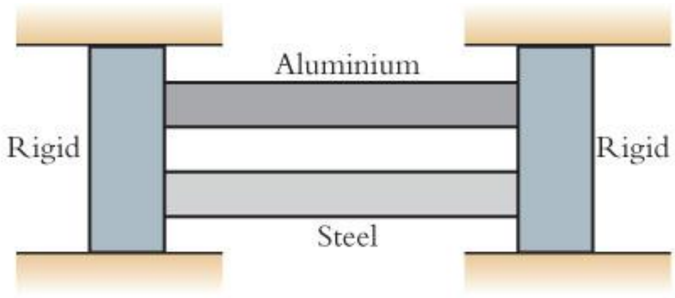


Fig. Q8

A. -25 MPa
B. -2.5 MPa
C. 1.25 MPa
D. 2.5 MPa
E. 25 MPa

9. If a component, for which $K_{max} = 1.33\sigma\sqrt{\pi a}$, has a crack in it of 1 mm length, and an applied stress of 850 MPa perpendicular to the crack surface, will it fracture?

Assume a fracture toughness for the material of $62\ \mathrm{MPa}\sqrt{\mathrm{m}}$.

A. Yes
B. -
C. -
D. -
E. No

10. Under fatigue, materials usually fail in three stages, the first being crack initiation and the final being final fracture. Between these two stages is:

A. Crack closure
B. Brittle failure
C. Ductile tearing
D. No change
E. Crack propagation

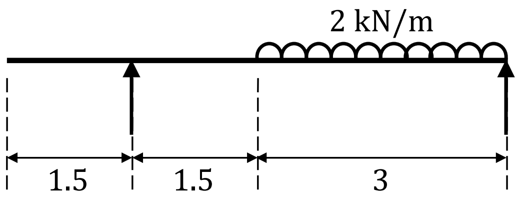
11. An unconstrained, 1.25 m long steel bar is subjected to a temperature change of 25°C, what is the change in length of the bar?
($\alpha = 11 \times 10^{-6}\,°C^{-1}$, $E = 200\ GPa$)

A. 0.34 m
B. 3.4 x 10^{-4} m
C. - 3.4 x 10^{-4} m
D. 13.75 mm
E. 3.4 x 10^{-4} mm

12. A solid bar of 40 mm diameter is subjected to a torque of 1.6 kNm. According to the Tresca yield criterion, does yielding occur if the uniaxial yield stress of the material is 250 MPa?

A. Yes
B. -
C. -
D. -
E. No

13. A 5 m long beam is supported at two positions and is subjected to a point load and a uniformly distributed load as shown in Fig. Q13. What is the reaction force at the right-hand support?



All dimensions in m

Fig. Q13

A. 8 kN
B. 3 kN
C. 2 kN
D. 4 kN
E. 6 kN

14. What is the reaction force at the left-hand support in Fig. Q13?

A. 8 kN
B. 3 kN
C. 2 kN
D. 4 kN
E. 6 kN

15. Which of the cross-sections shown in Fig. Q15 has the largest 2nd moment of area about the Y-Y axis?

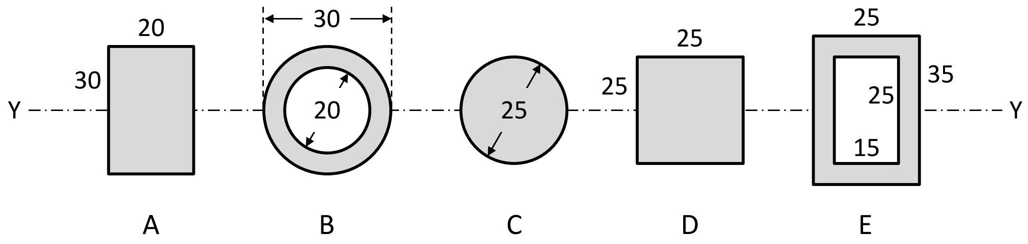


Fig. Q15

A. A
B. B
C. C
D. D
E. E

16. What would the diameter of a beam with a solid circular cross-section need to be in order to match the largest 2nd moment of area from Q15?

A. 690.6 mm
B. 309.4 mm
C. 345.3 mm
D. 227.2 mm
E. 454.4 mm

17. Fig. Q17 shows a plot of crack growth rate, $\frac{da}{dN}$, vs ΔK. The three curves were each produced using the same maximum fatigue load.

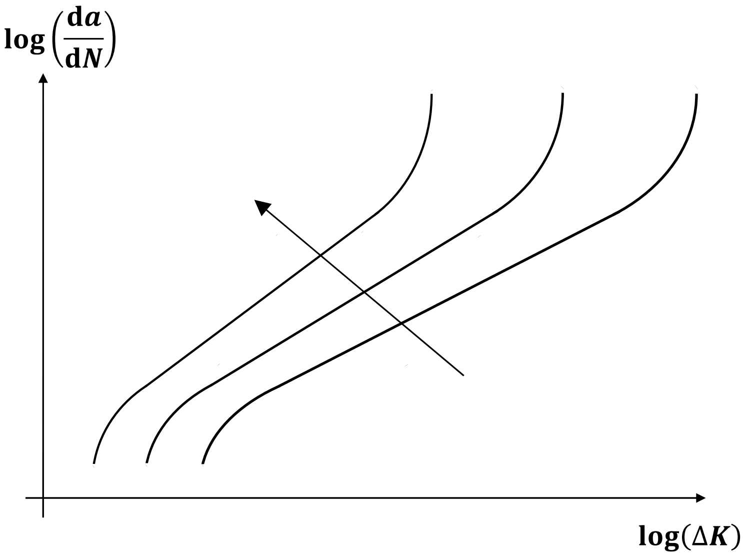


Fig. Q17

The arrow dissecting the curves indicates:

A. Constant mean load
B. Decreasing R-ratio
C. Increasing R-ratio
D. Constant minimum load
E. Constant R-ratio

18. What is the limiting pressure to avoid yielding for a steel pressure vessel 1.25 m in diameter and 3 mm thick according to the von Mises yield criterion? ($\sigma_y = 250\ MPa$)

A. 0.7 MPa
B. 0.8 MPa
C. 1.2 MPa
D. 1.4 MPa
E. 2.8 MPa

19. The 5mm diameter angled bar, ABC, shown in Fig. Q19 is subjected to a load, P, of 20 N. What is the maximum in-plane shear stress of a 2D plane stress element located on the top surface of the bar at point A?

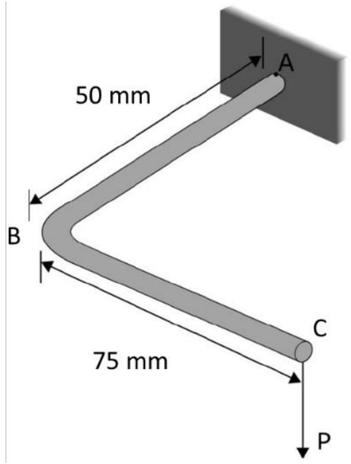


Fig. Q19

A. 73.4 MPa
B. 101.8 MPa
C. 61.1 MPa
D. 81.5 MPa
E. 40.8 MPa

20. What is the value of the maximum in-plane principal stress for the 2D plane-stress element shown in Fig. Q20?

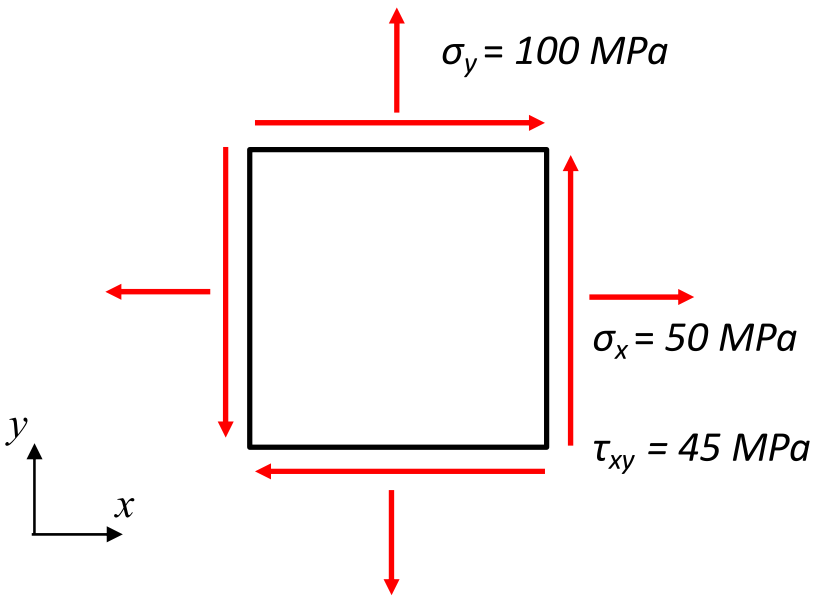


Fig. Q20

A. -23.5 MPa
B. 51.5 MPa
C. 75.0 MPa
D. 100 MPa
E. 126.5 MPa

END