The University of Nottingham

DEPARTMENT OF MECHANICAL, MATERIALS AND MANUFACTURING ENGINEERING

A LEVEL 2 MODULE, IN-CLASS TEST 2018-2019

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.

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 only FOUR possible answers to each question (A, B, C, D). ONLY ONE is correct in each case. If you do not know the answer you may choose not to guess. If so, you should use the abstain column (E).

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

Only silent, self-contained calculators with a Single-Line Display or Dual-Line Display are permitted in this examination.

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: None

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.

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

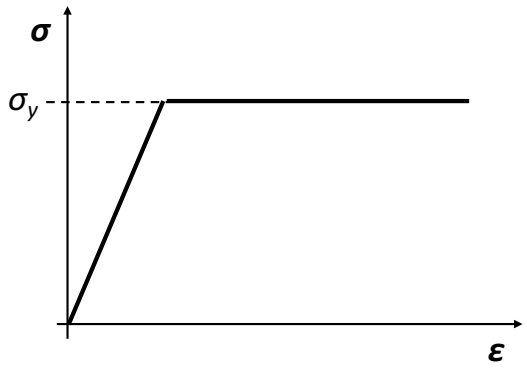


Fig. Q1

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

2. Fig. Q2 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. Taking the origin as the left-hand side of the beam, which of the following expresses the 2nd order differential equation for this beam?

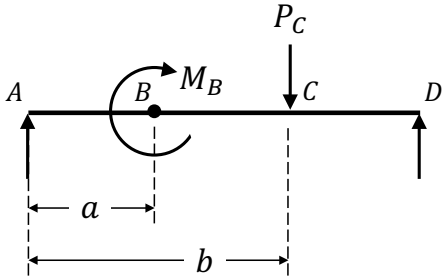


Fig. Q2

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

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

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

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

3. Fig. Q3 shows a schematic of a waveform for stress-controlled fatigue testing, where:

i. S_{min} = Minimum Stress
ii. S_{max} = Maximum Stress
iii. S_{mean} = Mean Stress
iv. S_{range} = Stress Range
v. S_{amp} = Stress Amplitude

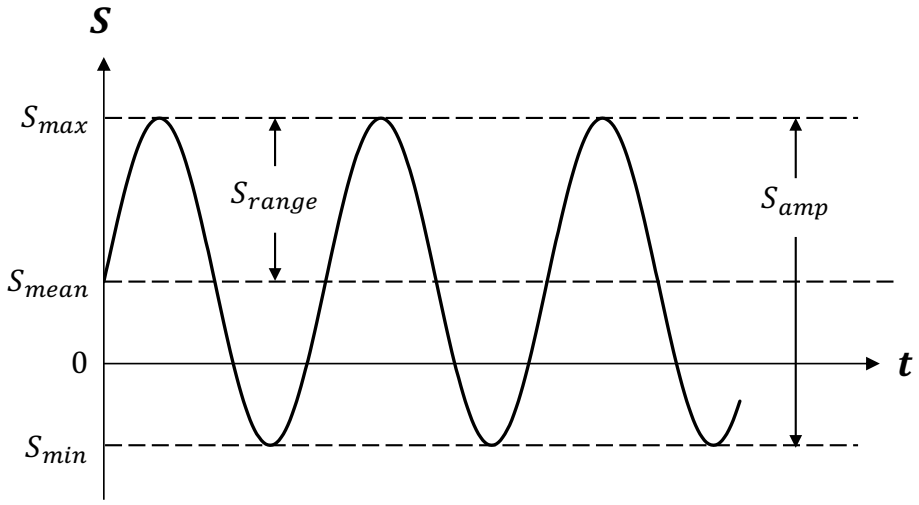


Fig. Q3

i to v are labelled correctly in Fig Q3.

A. True
B. -
C. -
D. False

4. What is the value of the maximum in-plane principal stress for the 2D plane-stress element shown in Fig. Q4?

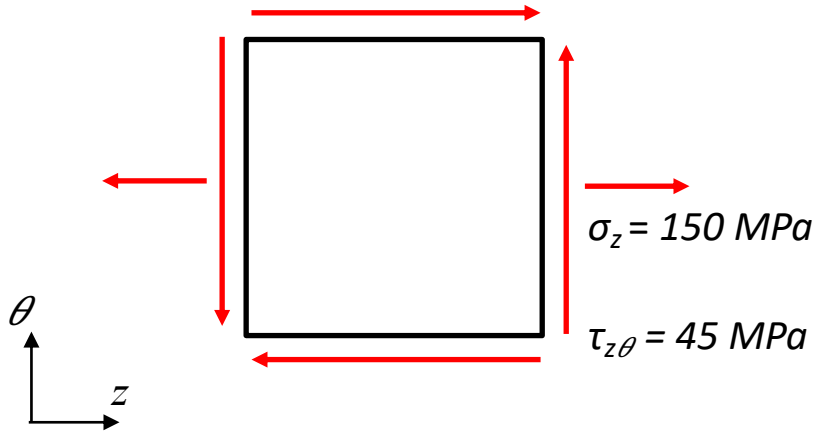


Fig. Q4

A. 195 MPa
B. 87 MPa
C. 75 MPa
D. 162 MPa

5. An unconstrained, 1m long copper bar is subjected to a temperature change of 50°C, what is the change in length of the bar? (a = 16 x 10^{-6}, E = 128 GPa)

A. – 0.5 x 10^{-3} m
B. 0.5 x 10^{-3} m
C. – 0.8 x 10^{-3} m
D. 0.8 x 10^{-3} m

6. If a beam under bending has the following 2nd order differential equation:

$$EI\frac{d^2y}{dx^2} = R_A x + P\langle x-4\rangle - w\frac{\langle x-8\rangle^2}{2}$$

What is the corresponding expression for deflection in the beam?

A. $y = R_A\frac{x^3}{6} + P\frac{\langle x-4\rangle^3}{6} - w\frac{\langle x-8\rangle^4}{24} + Ax + B$

B. $y = \frac{1}{EI}\left(R_A\frac{x^3}{6} + P\frac{\langle x-4\rangle^3}{6} - w\frac{\langle x-8\rangle^4}{24}\right)$

C. $\frac{dy}{dx} = \frac{1}{EI}\left(R_A\frac{x^2}{2} + P\frac{\langle x-4\rangle^2}{2} - w\frac{\langle x-8\rangle^3}{6} + A\right)$

D. $y = \frac{1}{EI}\left(R_A\frac{x^3}{6} + P\frac{\langle x-4\rangle^3}{6} - w\frac{\langle x-8\rangle^4}{24} + Ax + B\right)$

7. The deviatoric stress component in Fig. Q7 is indicated by:

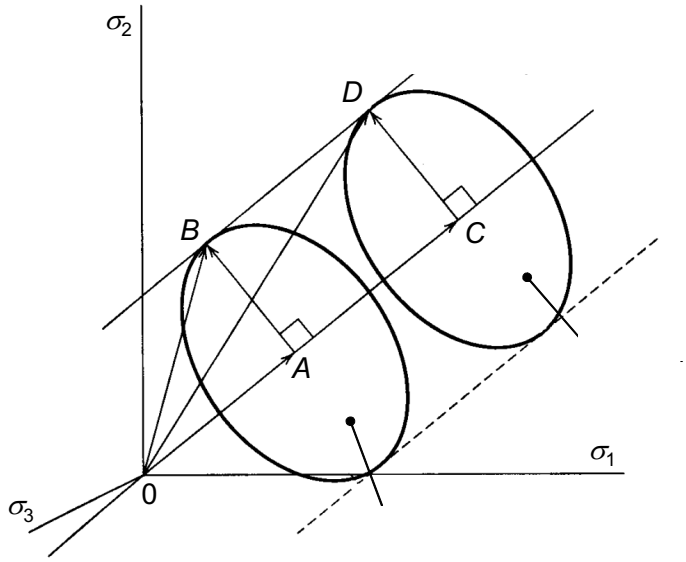


Fig. Q7

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

8. A bar of diameter 40 mm is subjected to a torque of 500 Nm and an axial load of 75 kN, the maximum shear stress of a 2D plane stress element on the surface of the bar is:

A. 40 MPa
B. 50 MPa
C. 80 MPa
D. 60 MPa

9. A pressure vessel of diameter 0.5 m is subjected to an internal pressure of 2 MPa. What is the minimum thickness to avoid yield considering the Tresca yield criterion, ensuring a safety factor of 2? (σ_y = 200 MPa)

A. 1×10^{-3} m
B. 5×10^{-3} m
C. 2.5×10^{-3} m
D. 1.5×10^{-2} m

10. If a component, for which $K_{max} = 1.25\sigma\sqrt{\pi a}$, has a crack in it of 0.75mm length, and an applied stress of 750MPa, will it fracture?

Assume a fracture toughness for the material of $55MPa\sqrt{m}$.

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

11. An increase in tensile mean stress on a component

A. has no effect on fatigue life

B. is detrimental to fatigue life

C. has the same effect as a compressive mean stress of the same magnitude on the fatigue life

D. is beneficial to the fatigue life

12. At what position, *a*, does yielding occur in the beam shown in Fig. Q12 if a pure bending moment, M, of 300kNm is applied? Fig. Q12 shows the stress distribution in the beam cross-section.

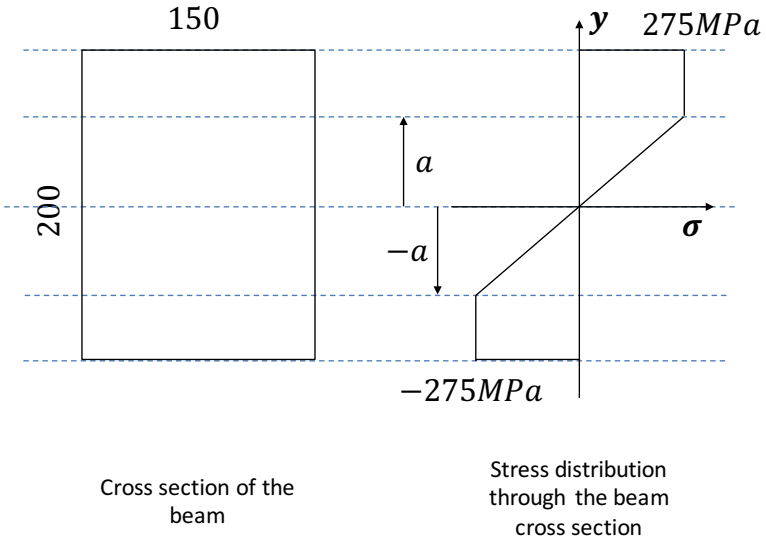


Fig. Q12

A. 45.23mm
B. 77.46mm
C. 100mm
D. 90.45mm

13. A shaft, made of a material with σ_y = 250 MPa, will carry a torque of 20kNm. According to the von Mises yield criterion, what should the radius be to avoid yielding?

A. 40 mm
B. 45 mm
C. 50 mm
D. 55 mm

14. A steel bar, constrained by rigid supports but under no load initially, is subjected to a temperature change of 25°C. What is the resultant stress in the bar? (α = 12 x 10^{-6}, E = 210 GPa)

A. 63 MPa
B. 72 MPa
C. – 63 MPa
D. – 72 MPa

15. The planes indicated A in figure Fig. Q15 are known as:

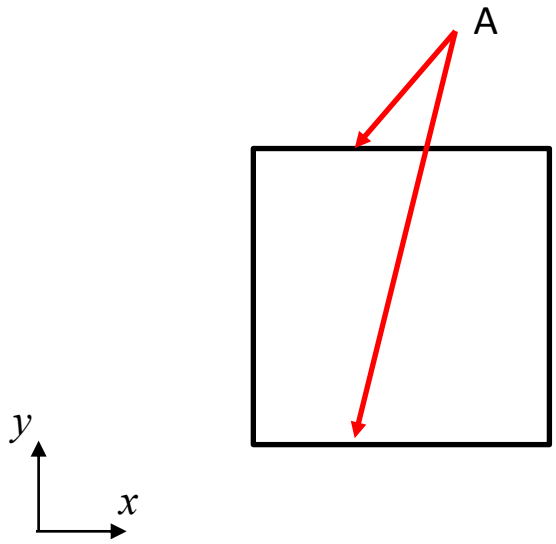
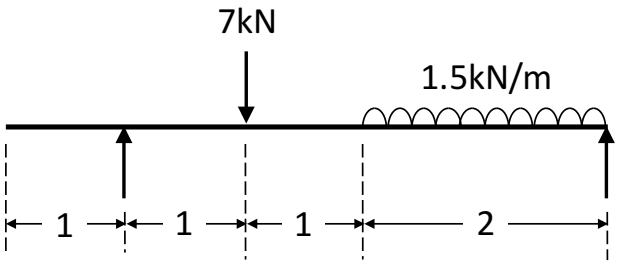


Fig. Q15

A. x-planes
B. y-planes
C. z-planes
D. θ-planes

16. A 5m long beam is supported at two positions and is subjected to a point load and a uniformly distributed load as shown in Fig. Q16. What is the reaction force at the left support?



All dimensions in m

Fig. Q16

A. 6kN
B. 5.63kN
C. 6.2kN
D. 4.8kN

17. The boundary conditions for the beam in Fig. Q16 are (taking the origin as the left-hand side of the beam):

i. at $x = 1$, $y = 0$

ii. at $x = 5$, $y = 0$

A. True
B. -
C. -
D. False

18. Compared to the von Mises yield criterion, the Tresca criterion is generally:

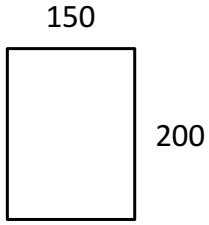
A. More conservative
B. Less conservative
C. The same
D. Not comparable at all

19. An aluminium rod with a cross-sectional area of 75 mm^2 is stretched between two fixed points, the tensile load at 20°C is 7500 N. If the temperature is increased by 20°C, what will be the stress in the bar? (a = 23 x 10^{-6}, E = 70 GPa)

A. 68 MPa
B. 63 MPa
C. – 68 MPa
D. – 63 MPa

20. If a beam has a rectangular cross-section, as shown in Fig. Q20, has a yield stress, σ_y, of 250MPa, and is subjected to a pure bending moment of 300kNm, does yielding occur?

Assume elastic-perfectly-plastic material behaviour.



All dimensions in mm

Fig. Q20

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

END