Edexcel AS Physics: Materials – Calculation Practice

Praneel Physics

1. A metal rod has a length of 2.0 m and a cross-sectional area of 0.01 m^2. If the rod is subjected to a tensile force of 1000 N, calculate the stress in the rod. **(P)**

Working and Answer:

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{1000\,\text{N}}{0.01\,\text{m}^2} = 100000\,\text{Pa}\,(100\,\text{kPa})$$

2. A wire has a diameter of 2.0 mm and is stretched by a force of 200 N. Calculate the strain in the wire if it extends by 1.0 mm. **(P)**

Working and Answer:
$\text{Area} = \frac{\pi d^2}{4} = \frac{\pi(0.002\,\text{m})^2}{4} = 3.14 \times 10^{-6}\,\text{m}^2; \text{Stress} = \frac{200\,\text{N}}{3.14 \times 10^{-6}\,\text{m}^2} = 636619.77\,\text{Pa}; \text{Strain} = \frac{\text{Extension}}{\text{Original Length}} = \frac{1.0\,\text{mm}}{1000\,\text{mm}} = 0.001$

3. A spring has a spring constant of 300 N/m. If the spring is compressed by 0.05 m, calculate the force exerted by the spring. **(P)**

Working and Answer:
$\text{Force} = k \cdot x = 300\,\text{N/m} \cdot 0.05\,\text{m} = 15\,\text{N}$

4. A material has a Young's modulus of 200 GPa. If a tensile stress of 50 MPa is applied, calculate the strain produced in the material. **(P)**

Working and Answer:

$$\text{Strain} = \frac{\text{Stress}}{Y} = \frac{50 \times 10^6\,\text{Pa}}{200 \times 10^9\,\text{Pa}} = 0.00025$$

5. A steel cable with a length of 10 m and a diameter of 10 mm is subjected to a tensile force of 5000 N. Calculate the extension of the cable if the Young's modulus of steel is 200 GPa. **(P)**

Working and Answer:
$\text{Area} = \frac{\pi(0.01\,\text{m})^2}{4} = 7.85 \times 10^{-5}\,\text{m}^2; \text{Stress} = \frac{5000\,\text{N}}{7.85 \times 10^{-5}\,\text{m}^2} =$
$637,755,102.04\,\text{Pa}; \text{Strain} = \frac{\text{Stress}}{Y} = \frac{637755102.04\,\text{Pa}}{200 \times 10^9\,\text{Pa}} =$
$0.00318877551; \text{Extension} = \text{Strain} \cdot \text{Original Length} = 0.00318877551 \cdot 10\,\text{m} =$
$0.0319\,\text{m}\,(31.9\,\text{mm})$

6. A beam of length 4.0 m and cross-sectional area $0.02\,\text{m}^2$ is subjected to a load of 8000 N. Calculate the stress in the beam. **(PP)**

Working and Answer:

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{8000\,\text{N}}{0.02\,\text{m}^2} = 400000\,\text{Pa}\,(400\,\text{kPa})$$

7. A rubber band is stretched from its original length of 0.5 m to 0.55 m. If the force applied is 10 N, calculate the strain in the rubber band. **(PP)**

Working and Answer:

$$\text{Strain} = \frac{\text{Extension}}{\text{Original Length}} = \frac{0.55\,\text{m} - 0.5\,\text{m}}{0.5\,\text{m}} = 0.1$$

8. A copper wire has a Young's modulus of 110 GPa. If a tensile stress of 70 MPa is applied, calculate the resulting strain. **(PP)**

Working and Answer:

$$\text{Strain} = \frac{\text{Stress}}{Y} = \frac{70 \times 10^6\,\text{Pa}}{110 \times 10^9\,\text{Pa}} = 0.00063636364$$

9. A cylindrical rod of length 1.0 m and diameter 0.01 m is subjected to a tensile force of 1000 N. Calculate the extension of the rod if the Young's modulus is 200 GPa. **(PP)**

Working and Answer:

$$\text{Area} = \frac{\pi(0.01\,\text{m})^2}{4} = 7.85 \times 10^{-5}\,\text{m}^2; \text{Stress} = \frac{1000\,\text{N}}{7.85 \times 10^{-5}\,\text{m}^2} =$$

$$127388.54\,\text{Pa}; \text{Strain} = \frac{127388.54\,\text{Pa}}{200 \times 10^9\,\text{Pa}} = 0.000636942; \text{Extension} =$$

$$\text{Strain} \cdot \text{Original Length} = 0.000636942 \cdot 1.0\,\text{m} = 0.000636942\,\text{m}\,(0.636942\,\text{mm})$$

10. A material has a Young's modulus of 150 GPa. If a tensile stress of 30 MPa is applied, calculate the strain produced in the material. **(PPP)**

Working and Answer:

$$\text{Strain} = \frac{\text{Stress}}{Y} = \frac{30 \times 10^6\,\text{Pa}}{150 \times 10^9\,\text{Pa}} = 0.0002$$

11. A steel cable with a length of 20 m and a diameter of 12 mm is subjected to a tensile force of 8000 N. Calculate the extension of the cable if the Young's modulus of steel is 200 GPa. **(PPP)**

Working and Answer:

$$\text{Area} = \frac{\pi(0.012\,\text{m})^2}{4} = 1.13 \times 10^{-4}\,\text{m}^2; \text{Stress} = \frac{8000\,\text{N}}{1.13 \times 10^{-4}\,\text{m}^2} =$$

$$707,106.78\,\text{Pa}; \text{Strain} = \frac{707106.78\,\text{Pa}}{200 \times 10^9\,\text{Pa}} = 0.0035355339; \text{Extension} =$$

$$\text{Strain} \cdot \text{Original Length} = 0.0035355339 \cdot 20\,\text{m} = 0.0707\,\text{m}\,(70.7\,\text{mm})$$

12. A beam of length 3.0 m and cross-sectional area 0.015 m^2 is subjected to a load of 6000 N. Calculate the stress in the beam. **(PPP)**

Working and Answer:

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{6000\,\text{N}}{0.015\,\text{m}^2} = 400000\,\text{Pa}\,(400\,\text{kPa})$$

13. A wire of length 2.0 m and diameter 1.0 mm is stretched by a force of 50 N. Calculate the extension of the wire if the Young's modulus is 200 GPa. **(PPP)**

Working and Answer:

$$\text{Area} = \frac{\pi(0.001\,\text{m})^2}{4} = 7.85 \times 10^{-7}\,\text{m}^2; \text{Stress} = \frac{50\,\text{N}}{7.85 \times 10^{-7}\,\text{m}^2} =$$

$$636619.77\,\text{Pa}; \text{Strain} = \frac{636619.77\,\text{Pa}}{200 \times 10^9\,\text{Pa}} = 0.0000031831; \text{Extension} =$$

$$\text{Strain} \cdot \text{Original Length} = 0.0000031831 \cdot 2.0\,\text{m} = 0.0000063662\,\text{m}\,(6.3662\,\text{mm})$$

14. A material has a Young's modulus of 100 GPa. If a tensile stress of 20 MPa is applied, calculate the strain produced in the material. **(PPPP)**

Working and Answer:

$$\text{Strain} = \frac{\text{Stress}}{Y} = \frac{20 \times 10^6\,\text{Pa}}{100 \times 10^9\,\text{Pa}} = 0.0002$$

15. A steel rod of length 5.0 m and diameter 0.02 m is subjected to a tensile force of 10000 N. Calculate the extension of the rod if the Young's modulus is 200 GPa. **(PPPP)**

Working and Answer:

$$\text{Area} = \frac{\pi(0.02\,\text{m})^2}{4} = 3.14 \times 10^{-4}\,\text{m}^2; \text{Stress} = \frac{10000\,\text{N}}{3.14 \times 10^{-4}\,\text{m}^2} =$$

$$318471.34\,\text{Pa}; \text{Strain} = \frac{318471.34\,\text{Pa}}{200 \times 10^9\,\text{Pa}} = 0.00000159236; \text{Extension} =$$

$$\text{Strain} \cdot \text{Original Length} = 0.00000159236 \cdot 5.0\,\text{m} = 0.0000079618\,\text{m}\,(7.9618\,\text{mm})$$

16. A beam of length 2.5 m and cross-sectional area 0.01 m^2 is subjected to a load of 5000 N. Calculate the stress in the beam. **(PPPP)**

Working and Answer:

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{5000\,\text{N}}{0.01\,\text{m}^2} = 500000\,\text{Pa}\,(500\,\text{kPa})$$

17. A wire of length 1.5 m and diameter 0.5 mm is stretched by a force of 30 N. Calculate the extension of the wire if the Young's modulus is 200 GPa. **(PPPP)**

Working and Answer:

$\text{Area} = \frac{\pi(0.0005\,\text{m})^2}{4} = 1.96 \times 10^{-7}\,\text{m}^2; \text{Stress} = \frac{30\,\text{N}}{1.96 \times 10^{-7}\,\text{m}^2} =$
$153,846,153.85\,\text{Pa}; \text{Strain} = \frac{153846153.85\,\text{Pa}}{200 \times 10^9\,\text{Pa}} = 0.00076923077; \text{Extension} =$
$\text{Strain} \cdot \text{Original Length} = 0.00076923077 \cdot 1.5\,\text{m} =$
$0.00115384615\,\text{m}\,(1.15384615\,\text{mm})$

18. A material has a Young's modulus of 250 GPa. If a tensile stress of 50 MPa is applied, calculate the strain produced in the material. **(PPPPP)**

Working and Answer:

$$\text{Strain} = \frac{\text{Stress}}{Y} = \frac{50 \times 10^6\,\text{Pa}}{250 \times 10^9\,\text{Pa}} = 0.0002$$

19. A steel rod of length 6.0 m and diameter 0.025 m is subjected to a tensile force of 15000 N. Calculate the extension of the rod if the Young's modulus is 200 GPa. **(PPPPP)**

Working and Answer:

$\text{Area} = \dfrac{\pi(0.025\,\text{m})^2}{4} = 4.91 \times 10^{-4}\,\text{m}^2; \text{Stress} = \dfrac{15000\,\text{N}}{4.91 \times 10^{-4}\,\text{m}^2} = 3,055,555.56\,\text{Pa}; \text{Strain} = \dfrac{3,055,555.56\,\text{Pa}}{200 \times 10^9\,\text{Pa}} = 0.00001527778; \text{Extension} = \text{Strain} \cdot \text{Original Length} = 0.00001527778 \cdot 6.0\,\text{m} = 0.00009166667\,\text{m}\,(0.09166667\,\text{mm})$

20. A beam of length 4.0 m and cross-sectional area $0.02\,\text{m}^2$ is subjected to a load of 10000 N. Calculate the stress in the beam. **(PPPPP)**

Working and Answer:

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{10000\,\text{N}}{0.02\,\text{m}^2} = 500000\,\text{Pa}\,(500\,\text{kPa})$$

21. A wire of length 3.0 m and diameter 1.5 mm is stretched by a force of 40 N. Calculate the extension of the wire if the Young's modulus is 200 GPa. **(PPPPP)**

Working and Answer:

$$\text{Area} = \frac{\pi(0.0015\,\text{m})^2}{4} = 1.77 \times 10^{-6}\,\text{m}^2; \text{Stress} = \frac{40\,\text{N}}{1.77 \times 10^{-6}\,\text{m}^2} =$$

$$226,757,369.61\,\text{Pa}; \text{Strain} = \frac{226757369.61\,\text{Pa}}{200 \times 10^9\,\text{Pa}} = 0.0011337868; \text{Extension} =$$

$$\text{Strain} \cdot \text{Original Length} = 0.0011337868 \cdot 3.0\,\text{m} = 0.00340136\,\text{m}\,(3.40\,\text{mm})$$