One Mentor Academy

A-LEVEL FOUNDATION & AS PHYSICS PREPARATION

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Topic: Materials & Solid Mechanics

FOUNDATION LEVEL

Instructions: Answer all 30 questions. This foundational worksheet tests core AS-Level concepts including density, basic Hooke's law, interpreting force-extension graphs, defining stress and strain, and calculating the Young modulus. All physical diagrams represent strictly geometrical and experimental fixtures without force vectors. Assume acceleration due to gravity $g = 9.81\ \mathrm{m\ s^{-2}}$ where required.

1 The diagram shows two solid rectangular blocks, A and B. Block A has mass m and volume V. Block B has mass $2m$ and volume $\frac{V}{2}$. What is the ratio of the density of Block B to the density of Block A ($\rho_B : \rho_A$)?



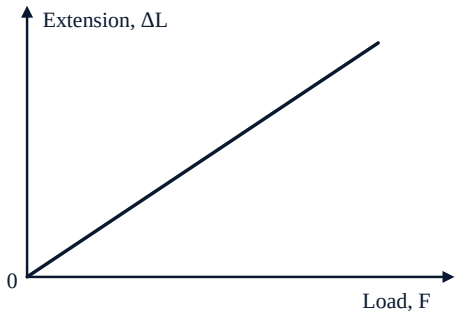
A. 1 : 1

B. 2 : 1

C. 4 : 1

D. 1 : 4

2 The graph shows the extension ΔL of a spring against the applied load F. The material obeys Hooke's Law perfectly in the region shown. What does the gradient (slope) of this specific graph mathematically represent?



A. The spring constant, k

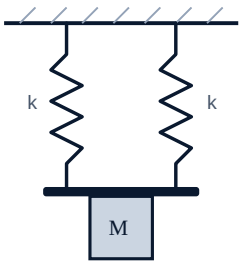
B. The inverse of the spring constant, $\frac{1}{k}$

C. The elastic strain energy stored

D. The Young modulus of the spring material

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3 Two identical light springs, each with a spring constant k, are connected in parallel and suspended from a rigid ceiling. A block of mass M is hung from the bottom crossbar. What is the total effective spring constant of this arrangement?



A. $\frac{1}{2}k$

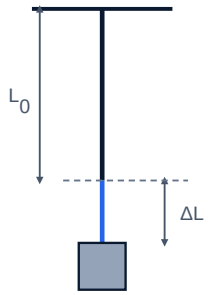
B. k

C. $2k$

D. $4k$

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4 A cylindrical metal wire is suspended vertically. It has an original resting length L_0. When a block is attached to the bottom, the wire stretches elastically by an amount ΔL. Which expression strictly defines the tensile strain ε experienced by the wire?



A. $\varepsilon = \frac{L_0}{\Delta L}$

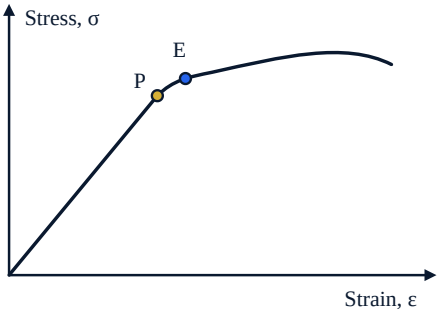
B. $\varepsilon = \frac{\Delta L}{L_0}$

C. $\varepsilon = \Delta L \times L_0$

D. $\varepsilon = \frac{\Delta L}{L_0 + \Delta L}$

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5 The graph shows a typical stress-strain curve for a ductile metal wire. Point P represents the limit of proportionality, and Point E represents the elastic limit. What is the physical significance of the region between point P and point E?



A. The wire undergoes permanent plastic deformation.

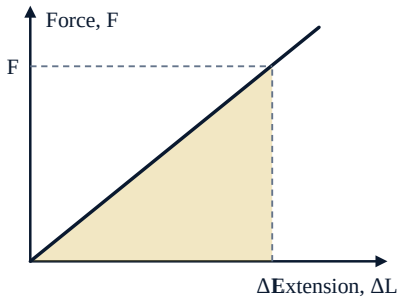
B. Hooke's law is obeyed, but the wire will not return to its original length.

C. Hooke's law is no longer strictly obeyed, but the wire will still return to its original length if the load is removed.

D. The material begins to neck and fracture.

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6 A material is stretched up to a load F with a corresponding extension ΔL without exceeding its limit of proportionality. What physical quantity is represented by the shaded triangular area under the force-extension graph?



A. The Young modulus of the material.

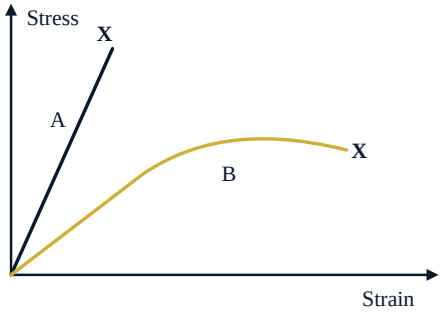
B. The elastic strain energy stored in the material.

C. The rate of change of stiffness.

D. The tensile stress applied to the material.

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7 The graph below shows the stress-strain behavior of two different solid materials, A and B, tested until they fracture (marked with an 'X'). Based strictly on the shape of these curves, how would you classify materials A and B?



A. A is ductile and B is brittle.

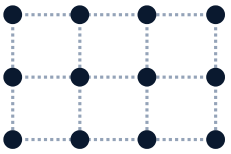
B. A is brittle and B is ductile.

C. Both A and B are perfectly brittle.

D. Both A and B are polymeric.

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8 The diagram provides a highly magnified, simplified 2D view of atoms in a metallic crystal lattice. When a small tensile stress is applied within the elastic limit, what is happening on this microscopic level?



A. Whole planes of atoms are sliding past each other permanently.

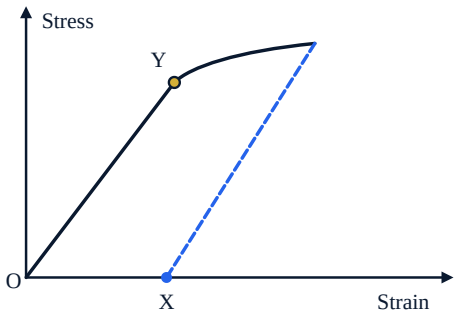
B. The atomic bonds are slightly stretching, but will return to their original equilibrium spacing once stress is removed.

C. The atomic bonds are breaking completely to form a liquid phase.

D. The mass of the individual atoms is temporarily increasing.

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9 A sample of metal wire is loaded beyond its elastic limit (Point Y) and then the load is completely removed. The graph shows the path taken during loading and unloading. What physical measurement does the distance OX on the strain axis represent?



A. The elastic limit of the material.

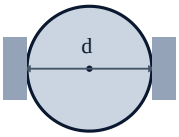
B. The permanent plastic strain (permanent set) left in the wire.

C. The ultimate tensile strain before fracture.

D. The total elastic strain recovered.

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10 In an experiment to determine the Young modulus of a wire, a student uses a micrometer screw gauge to measure the diameter d of the wire's circular cross-section. Which formula must the student use to correctly calculate the cross-sectional area A?



A. $A = \pi d^2$

B. $A = 2\pi d$

C. $A = \frac{\pi d^2}{4}$

D. $A = \frac{\pi d}{2}$

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11 A spring has a natural resting length of $0.20\ \text{m}$ and a spring constant of $50\ \text{N m}^{-1}$. What is the total length of the spring when a stretching force of $10\ \text{N}$ is applied? (Assume the spring obeys Hooke's Law.)

A. $0.20\ \text{m}$

B. $0.40\ \text{m}$

C. $0.50\ \text{m}$

D. $1.00\ \text{m}$

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12 A steel cable has a uniform cross-sectional area of $2.0 \times 10^{-4}\ \text{m}^2$. It supports a static load that creates a tensile force of $5000\ \text{N}$. What is the tensile stress in the cable?

A. $1.0 \times 10^7\ \text{Pa}$

B. $2.5 \times 10^7\ \text{Pa}$

C. $2.5 \times 10^8\ \text{Pa}$

D. $5.0 \times 10^8\ \text{Pa}$

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13 A nylon string of original length $1.50\ \text{m}$ is stretched by an external force until its length is $1.53\ \text{m}$. What is the tensile strain in the string?

A. 0.02

B. 0.03

C. 0.20

D. 0.98

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14 Which of the following equations correctly defines the Young modulus E of a material, where F is force, L is original length, A is cross-sectional area, and ΔL is extension?

A. $E = \frac{F\Delta L}{AL}$

B. $E = \frac{FL}{A\Delta L}$

C. $E = \frac{A\Delta L}{FL}$

D. $E = \frac{FA}{L\Delta L}$

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15 What is the SI unit for the Young modulus?

A. Newtons (N)

B. Joules (J)

C. Pascals (Pa) or $\mathrm{N\ m^{-2}}$

D. It is a dimensionless quantity (no units)

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16 A spring with a spring constant of $400\ \mathrm{N\ m^{-1}}$ is extended elastically by $0.10\ \mathrm{m}$. How much elastic strain energy is stored in the spring?

A. $2.0\ \mathrm{J}$

B. $4.0\ \mathrm{J}$

C. $20\ \mathrm{J}$

D. $40\ \mathrm{J}$

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17 A wire of length L and cross-sectional area A stretches by an amount e when a force F is applied. A second wire made of the identical material has length $2L$ and the same cross-sectional area A. If the same force F is applied, what will be its extension?

A. $\frac{1}{2}e$

B. e

C. $2e$

D. $4e$

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18 A wire of diameter d stretches by x under a force F. If a wire of the exact same material and length, but with a diameter of $2d$, is subjected to the same force F, what will be its extension?

A. $2x$

B. x

C. $\frac{1}{2}x$

D. $\frac{1}{4}x$

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19 When a metal wire is stretched significantly beyond its elastic limit to fracture, what happens to the majority of the work done stretching the wire during the plastic deformation phase?

A. It is stored entirely as recoverable elastic strain energy.

B. It is destroyed and disappears from the universe.

C. It is dissipated as thermal energy (heat) due to internal atomic friction/rearrangement.

D. It converts into kinetic energy, causing the wire to vibrate indefinitely.

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20 An alloy is made by mixing $2.0\ \mathrm{m}^3$ of metal X (density $3000\ \mathrm{kg\ m^{-3}}$) and $3.0\ \mathrm{m}^3$ of metal Y (density $8000\ \mathrm{kg\ m^{-3}}$). Assuming the total volume is conserved, what is the density of the resulting alloy?

A. $5500\ \mathrm{kg\ m^{-3}}$

B. $6000\ \mathrm{kg\ m^{-3}}$

C. $6500\ \mathrm{kg\ m^{-3}}$

D. $11000\ \mathrm{kg\ m^{-3}}$

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21 Two springs, P and Q, have spring constants of $200\ \mathrm{N\ m^{-1}}$ and $300\ \mathrm{N\ m^{-1}}$ respectively. If they are connected in series (end-to-end) and pulled with a force, what is the effective spring constant of the combination?

A. $100\ \mathrm{N\ m^{-1}}$

B. $120\ \mathrm{N\ m^{-1}}$

C. $250\ \mathrm{N\ m^{-1}}$

D. $500\ \mathrm{N\ m^{-1}}$

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22 On a stress-strain graph, the maximum stress a material can withstand before necking and eventual fracture occurs is known as:

A. The Proportionality Limit

B. The Elastic Limit

C. The Yield Stress

D. The Ultimate Tensile Strength (UTS)

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23 A strip of rubber is stretched and then allowed to contract. The force-extension graph forms a loop (a hysteresis loop). The area enclosed inside this loop represents:

A. The total work done in stretching the rubber.

B. The elastic energy perfectly recovered during contraction.

C. The thermal energy dissipated during one full stretch-contract cycle.

D. The Young modulus of the rubber.

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24 Which of the following best defines the 'Elastic Limit' of a material?

A. The point up to which stress is directly proportional to strain.

B. The maximum stress a material can bear without snapping.

C. The point beyond which the material will no longer return to its original length when the load is removed.

D. The point where a large increase in strain occurs with little or no increase in stress.

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25 An ideal spring of length L has a spring constant k. If the spring is cut precisely in half, what is the spring constant of one of the resulting shorter springs?

A. $\frac{1}{2}k$

B. k

C. $2k$

D. $4k$

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26 A material (such as polythene) extends significantly under a small stress, does not obey Hooke's law, and deforms plastically very easily without breaking immediately. Which term best describes this material behavior?

A. Brittle

B. Stiff

C. Polymeric / Ductile

D. Perfectly Elastic

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27 A metal block has a mass of $4000\ \text{kg}$ and outer dimensions of $1\ \text{m} \times 2\ \text{m} \times 1\ \text{m}$. However, the block is hollow inside, with the hollow cavity having a volume of $0.5\ \text{m}^3$. What is the true density of the metal making up the block?

A. $1600\ \text{kg m}^{-3}$

B. $2000\ \text{kg m}^{-3}$

C. $2667\ \text{kg m}^{-3}$

D. $8000\ \text{kg m}^{-3}$

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28 A student calculates the Young modulus of a mystery metal wire and finds it to be $2.1 \times 10^{11}\ \text{Pa}$ (or $210\ \text{GPa}$). Which common engineering material is this most likely to be?

A. Rubber

B. Lead

C. Glass

D. Steel

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29 During a tensile test on a low-carbon steel sample, the material passes the elastic limit and reaches a point where the strain suddenly increases significantly without any noticeable increase in the applied stress. What is this specific behavior called?

A. Necking

B. Yielding

C. Fracturing

D. Work hardening

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30 When a rubber cord is stretched within its elastic limit, its length increases while its cross-sectional area decreases. Assuming the volume of the rubber remains completely constant during this stretch, what is the value of its Poisson's ratio? (Note: Poisson's ratio relates transverse strain to longitudinal strain).

A. 0.0

B. 0.3

C. 0.5

D. 1.0

Comprehensive Answer Key

Verified for A-Level Standards

Q1: **C**	Q2: **B**	Q3: **C**	Q4: **B**	Q5: **C**	Q6: **B**	Q7: **B**	Q8: **B**	Q9: **B**	Q10: **C**
Q11: **B**	Q12: **B**	Q13: **A**	Q14: **B**	Q15: **C**	Q16: **A**	Q17: **C**	Q18: **D**	Q19: **C**	Q20: **B**
Q21: **B**	Q22: **D**	Q23: **C**	Q24: **C**	Q25: **C**	Q26: **C**	Q27: **C**	Q28: **D**	Q29: **B**	Q30: **C**