Worksheet: Stress, Strain, and Elastic Modulus

Q1: The bulk modulus of a material is 10^{11} N/m^2. What is the percent change in volume of a piece of this material when it is subjected to a bulk stress increase of 10^7 N/m^2? Assume that the force is applied uniformly over the surface.

Question Video

A 0.01%

B 0.001%

C 0.03%

D 0.004%

E 0.02%

Q2: A nylon rope has a Young's Modulus of 1.35×10^9 Pa, a length of 35.0 m when not stretched, and a diameter of 0.800 cm. If a mountain climber of mass 65.0 kg hangs on this rope, how much does it extend?

Question Video

A 32.9 cm

B 30.3 cm

C 34.5 cm

D 36.2 cm

E 28.5 cm

Q3: Two rods, one made of brass and the other of lead, have the same dimensions. When a particular stress is applied to the brass rod, it stretches by 0.18 mm. How much does the lead rod stretch under the same stress? Use a value of 9.0×10^{10} Pa for the Young's modulus of brass and use a value of 1.6×10^{10} Pa for the Young's modulus of lead.

A 1.0 mm

B 0.030 mm

C 0.18 mm

D 0.10 mm

E 10 mm

Q4: Two thin rods, one made of steel and the other of aluminum, are joined end to end. Each rod is 2.0 m long and has cross-sectional area of 9.1 mm^2. A tensile force of 10 kN is applied at each end of the combination. Use a value of 2.0×10^{11} Pa for the Young's modulus of steel and a use a value of 7.0×10^{10} Pa for the Young's modulus of aluminum to determine the effects of the force on the rods.

- Find the stress in the rods.

A 0.88×10^9 N/m^2

B 1.6×10^9 N/m^2

C 1.1×10^9 N/m^2

D 0.93×10^9 N/m^2

E 1.9×10^9 N/m^2

Find the strain in the rods.

A 5.8×10^{-3}

B 6.8×10^{-3}

C 5.5×10^{-3}

D 6.3×10^{-3}

E 7.5×10^{-3}

Find the elongation of the steel rod.

A 8.3 mm

B 10 mm

C 11 mm

D 9.7 mm

E 14 mm

Find the elongation of the aluminum rod.

A 19 mm

B 37 mm

C 31 mm

D 25 mm

E 42 mm

Q5: During a walk on a rope, a tightrope walker creates a tension of 3.94×10^3 N in a steel wire that is stretched between two supporting poles that are 15.0 m apart. The wire has a diameter of 0.500 cm when it is not stretched. When the walker is on the wire in the middle between the poles the wire makes an angle of 50.00° below the horizontal. Under tension, steel has a Young's modulus of 20.0×10^{10} Pa. How much does the tension in the wire stretch the wire when the walker is this position?

A 1.39 cm

B 0.386 cm

C 2.32 cm

D 2.67 cm

E 1.50 cm

Q6: A copper wire is 1 000.0 mm long and its diameter is 1.000 mm. The wire hangs vertically. Determine how much weight must be added to its free end in order to extend its length 3.0 mm. Use a value of 1.10×10^{11} Pa for the Young's modulus of copper. Ignore any extension of the wire by its own weight.

A 259 N

B 262 N

C 257 N

D 252 N

E 255 N

Q7: As an oil well is drilled, each new section of drill pipe supports its own weight and the weight of the pipe and the drill bit beneath it. Calculate the stretch in a new 6.00 m-long steel pipe that supports a 100 kg mass drill bit and a 3.00×10^3 m length of pipe with a linear mass density of 20.0 kg/m. Treat the pipe as a solid cylinder with a 5.00 cm diameter. The Young's Modulus of Steel is 209×10^9 Pa.

A 9.36 mm

B 8.59 mm

C 9.67 mm

D 9.02 mm

E 9.88 mm

Q8: A 30.0-m-long nylon rope has a diameter of 1.000 cm. A mountain climber of mass 90.0 kg hangs from the rope, extending it by 25.0 cm. What is the Young's modulus of the nylon in the rope?

A 1.68×10^9 Pa

B 1.35×10^9 Pa

C 1.41×10^9 Pa

D 1.50×10^9 Pa

E 1.77×10^9 Pa

Q9: The "lead" in pencils is a graphite composition with a Young's modulus of 1.0×10^9 N/m^2. Calculate the change in length of the lead in an automatic pencil when it is tapped straight into the pencil with a force of 4.0 N. The lead is 0.50 mm in diameter and 60 mm long.

A 1.4 mm

B 0.91 mm

C 1.2 mm

D 1.0 mm

E 0.86 mm

Q10: A 20.0-m-tall hollow aluminum flagpole is equivalent in strength to a solid cylinder 4.00 cm in diameter. A strong wind bends the pole equivalently to a horizontal 900.0-N force acting on the the top of the pole. How far to the side does the top of the pole flex? Use a value of 2.5×10^{10} Pa for the shear modulus of aluminum.

A 0.57 mm

B 0.55 mm

C 0.63 mm

D 0.53 mm

E 0.59 mm

Q11: A steel suspension rod of a suspension bridge is 23 m long. The suspension rod must not stretch by more than 1.1 cm when a truck with a mass of 3.5×10^4 kg passes over the section of the bridge suspended from the rod. What diameter must the rod have if it supports the entire weight of such a truck? Use a value of 2.0×10^{11} Pa for the Young's modulus of steel.

A 13 cm

B 5.6 cm

C 1.0 cm

D 6.8 cm

E 3.5 cm

Q12: A physicist with a mass of 78.0 kg places himself and 5.0×10^2 kg of equipment at the top of a 640 m high TV broadcast antenna to perform experiments on gravity. If the antenna is modeled as a steel cylinder of radius 0.1700 m, by how much is it compressed due to the weight of the physicist and his equipment? Use a value of 2.0×10^{11} Pa for the Young's modulus of steel.

A 0.17 mm

B 0.20 mm

C 10 mm

D 0.10 mm

E 20 mm

Q13: A piano tuner applies a force to stretch a steel piano wire with a 0.9200 mm diameter by 9.00 mm. The unextended wire length is 1.55 m. Calculate the magnitude of the tension in the wire during stretching. Use a value of 2.00×10^{11} Pa for the Young's modulus of steel.

A 958 N

B 832 N

C 772 N

D 0.772 N

E 0.832 N

Q14: Normal forces of magnitude 1.0×10^{6} N are applied uniformly to a spherical surface enclosing a volume of a liquid. This causes the radius of the surface to decrease from 60.0000 cm to 59.9960 cm. What is the bulk modulus of the liquid?

A 1.2×10^{9} Pa

B 9.0×10^{10} Pa

C 1.2×10^{10} Pa

D 1.3×10^{11} Pa

E 1.1×10^{11} Pa

Q15: A copper wire is suspended from the ceiling and hangs vertically. How long must the wire be before the stress at its upper end reaches the proportionality limit of 7.0×10^7 N/m^2? Use a value of 8.96 g/cm^3 for the density of copper.

A 800 m

B 950 m

C 730 m

D 860 m

E 780 m

Q16: A uniform rope of cross-sectional area 0.600 cm^2 breaks when the tensile stress in it reaches 7.2×10^6 N/m^2.

What is the maximum load that can be lifted slowly at a constant speed by the rope?

A 1.2 N

B 140 N

C 130 N

D 12 N

E 430 N

What is the maximum load that can be lifted by the rope with an acceleration of 4.0 m/s^2?

A 96 N

B 13 N

C 9.6 N

D 1.2 N

E 310 N

Q17: A 4.0×10^2 N weight is suspended from a wire, stretching the wire by 3.5 mm. The diameter of the wire is 1.20 mm and the unextended length of the wire is 2.0 m. What is the Young's modulus of the metal used to manufacture the wire?

A 2.0×10^{11} Pa

B 2.1×10^{11} Pa

C 1.0×10^{11} Pa

D 5.0×10^{10} Pa

E 1.5×10^{11} Pa

Q18: When bismuth freezes, its volume increases by 3.32%. What magnitude of force per unit area is bismuth capable of exerting on a container when it freezes? Use a value of 3.40×10^{10} Pa for the bulk modulus of bismuth.

A 3.29×10^{8} N/m^2

B 1.13×10^{8} N/m^2

C 4.53×10^{8} N/m^2

D 1.13×10^{6} N/m^2

E 4.53×10^{10} N/m^2

Q19: A boy with a mass of 35 kg falls vertically downward through 3.7 m. The boy lands on one foot and comes to rest in 0.12 s after he hits the ground, decelerating uniformly. The total cross-sectional area of the bones in the boy's legs just above his ankles is 3.4 cm^2. What is the compressive stress in these bones?

A 1.8×10^{6} Pa

B 8.0×10^{6} Pa

C 7.3×10^{6} Pa

D 5.8×10^{6} Pa

E 3.3×10^{6} Pa

Q20: A copper wire of diameter 1.20 cm extends by 1.1% when it is used to lift a load vertically upward with an acceleration of 2.5 m/s^2. Find the weight of the load. Use a value of 1.1×10^{11} Pa for the Young's modulus of copper.

A 11 kN

B 110 kN

C 37 kN

D 190 kN

E 550 kN

Q21: A disk between vertebrae in the spine is subjected to a shearing force of 7.00×10^2 N. The disk is equivalent to a solid cylinder 0.650 cm high and 3.800 cm in diameter. Find its shear deformation. Use a value of 1.00×10^9 N/m^2 for the shear modulus of the disk.

A 1.00×10^{-4} cm

B 4.01×10^{-4} cm

C 1.53×10^{-4} cm

D 4.01×10^{-3} cm

E 1.50×10^{-4} cm

Q22: A cube of steel with a volume of 1.0 m^3 is placed in a fluid that is compressed, applying a force of 1.0×10^7 N to each of the cube's faces. Find the reduction in the volume of the cube. Use a value of 1.6×10^{11} for the bulk modulus of steel.

A $1.9 \times 10^{-5}\ m^3$

B $5.4 \times 10^{-4}\ m^3$

C $3.8 \times 10^{-4}\ m^3$

D $6.3 \times 10^{-5}\ m^3$

E $1.6 \times 10^{-3}\ m^{-3}$

Q23: A wire that is 2.0 m long has a load suspended from it and the wire extends by 1.0 mm. What is the wire's tensile strain?

A 5.0×10^{-3}

B 5.0×10^{-4}

C 2.5×10^{-4}

D 2.0×10^{-4}

E 1.0×10^{-4}

Q24: A sculpture that has a weight of 10.0 kN rests on the level top of a 6.00 m high vertical column that has a cross-sectional area of 0.200 m^2. The column has a density of 2 700 kg/m^3.

What is the compressive stress applied to a cross-sectional layer of the column 3.0 m below the base of the sculpture?

A 156 kPa

B 157 kPa

C 78.4 kPa

D 128 kPa

E 256 kPa

Find the compressive strain of the column section extending from the base of the sculpture to 3.0 m vertically below that point. Use a value of 4.50×10^7 kPa for the Young's modulus of granite.

A 3.02×10^{-6}

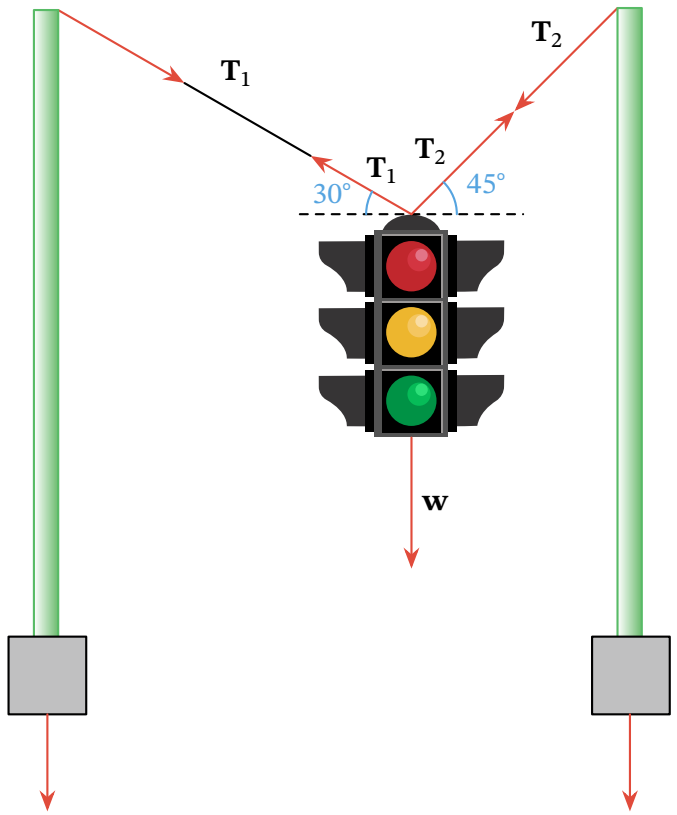
B 3.48×10^{-6}

C 2.30×10^{-6}

D 2.85×10^{-6}

E 2.98×10^{-6}

Q25: The figure shows a set of traffic lights suspended by two wires attached to posts at the sides of the road. The left wire makes an angle of 30.0° above the horizontal and carries a tension of 125 N. The left post is a 14.0 m tall hollow aluminum pole and is equivalent in strength to a 6.50 cm diameter solid cylinder. The Young's modulus of aluminum is 70.0×10^9 N/m^2 and the shear modulus is 25.0×10^9 N/m^2.



How far is the left post bent to the side?

A 1.83×10^{-5} m

B 1.66×10^{-5} m

C 1.43×10^{-5} m

D 5.27×10^{-6} m

E 2.97×10^{-7} m

By how much is the left post compressed?

A 3.77×10^{-6} m

B 1.22×10^{-7} m

C 1.92×10^{-7} m

D 1.71×10^{-7} m

E 4.57×10^{-6} m