Institut Teknologi Sepuluh Nopember
Surabaya

Fisika Rekayasa I

Seri:

ELASTISITAS

MODULUS YOUNG

Oleh: Aulia Siti Aisjah
Tutug Dhanardono

OUT LINE

- Pengantar
- Materi
  - Elastisitas
  - Stress
  - Strain
  - Modulus Elastisitas
- Contoh Soal
- Ringkasan
- Latihan
- Asesmen

Capaian Pembelajaran:
Mahasiswa mampu menjelaskan konsep elastisitas suatu bahan

Nilai **Tegangan** yang kecil, benda tegar bersifat “**elastis**”. Faktor perbandingan antara tegangan dan regangan didefenisikan sebagai modulus elastisitas.

Tegangan = modulus elastisitas × Regangan

Modulus Elastisitas

Modulus Young:	Menggambarkan keuletan bahan, Modulus Young besar, bahan semakin susah ditarik / ditekan.
Modulus Geser:	Menggambarkan kekakuan bahan, Modulus Geser besar, bahan semakin susah di puntir.
Modulus Bulk:	Menggambarkan kemampuan bahan untuk dimampatkan.

Stress = Modulus x Strain

Tegangan (stress) Normal $= \dfrac{F_\perp}{A}$ $\quad \boldsymbol{F} \perp \boldsymbol{A}$, gaya normal

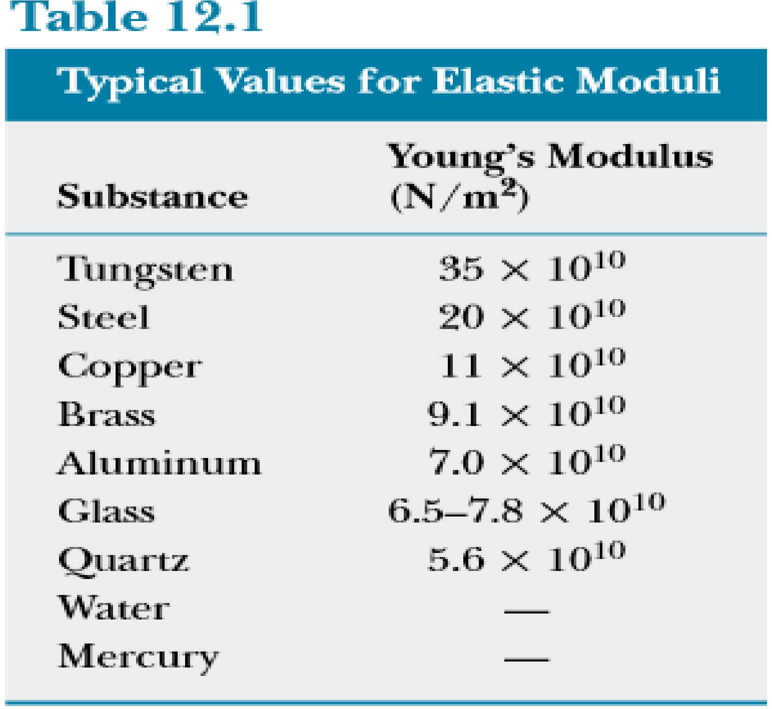


Table 12.1

Typical Values for Elastic Moduli

Substance	Young's Modulus (N/m²)
Tungsten	35×10^{10}
Steel	20×10^{10}
Copper	11×10^{10}
Brass	9.1×10^{10}
Aluminum	7.0×10^{10}
Glass	$6.5\text{–}7.8 \times 10^{10}$
Quartz	5.6×10^{10}
Water	—
Mercury	—

$$\frac{F_\perp}{A} = E\,\frac{\Delta L}{L_0}$$

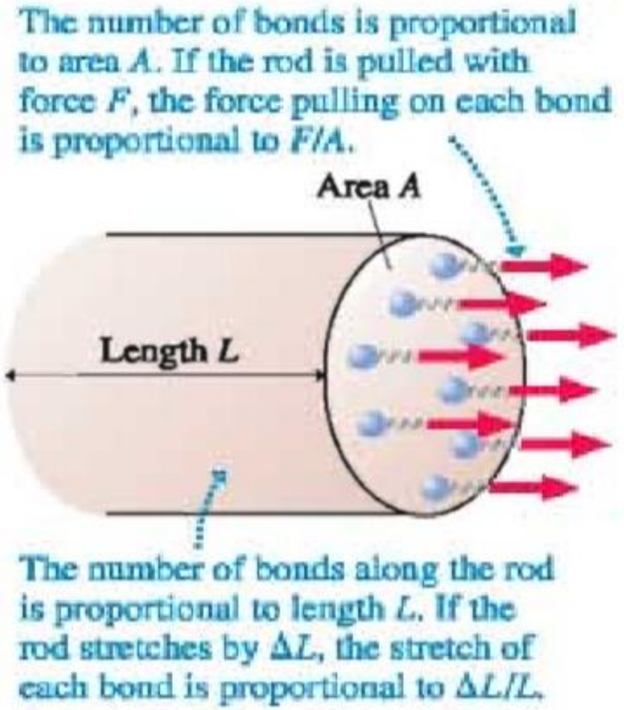
Tegangan

Regangan

***E*: Modulus Young**

Dimensi sama dengan tegangan

FIGURE 15.38 A material's elasticity is directly related to the spring constant of the molecular bonds.

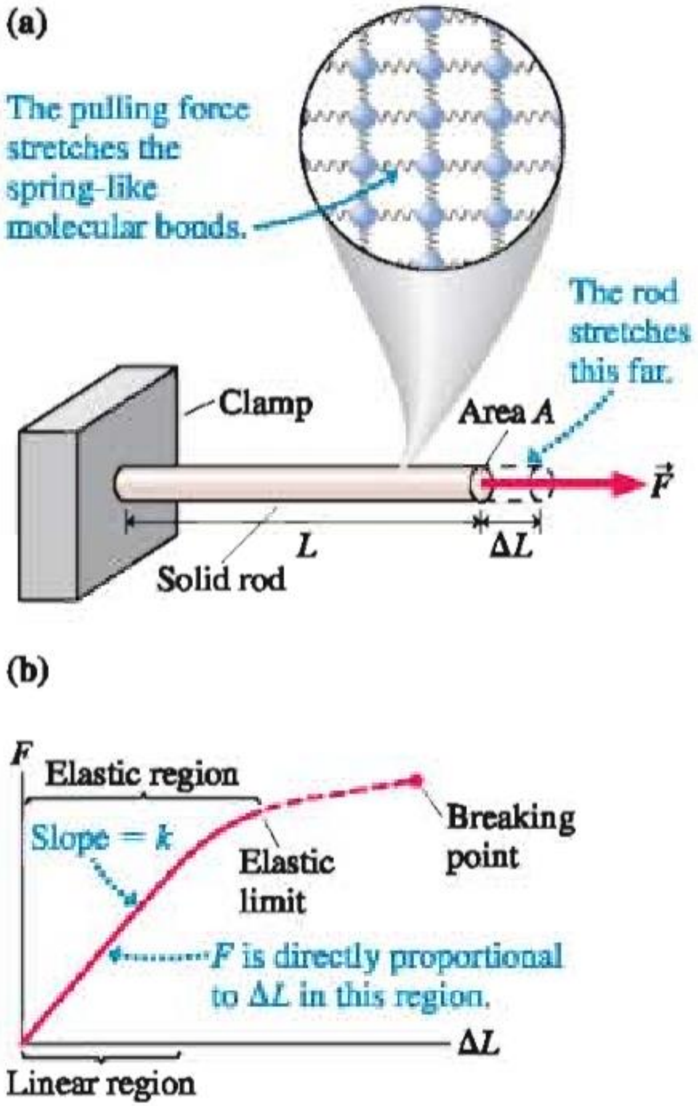


$$\frac{F}{A} = Y\frac{\Delta L}{L}$$

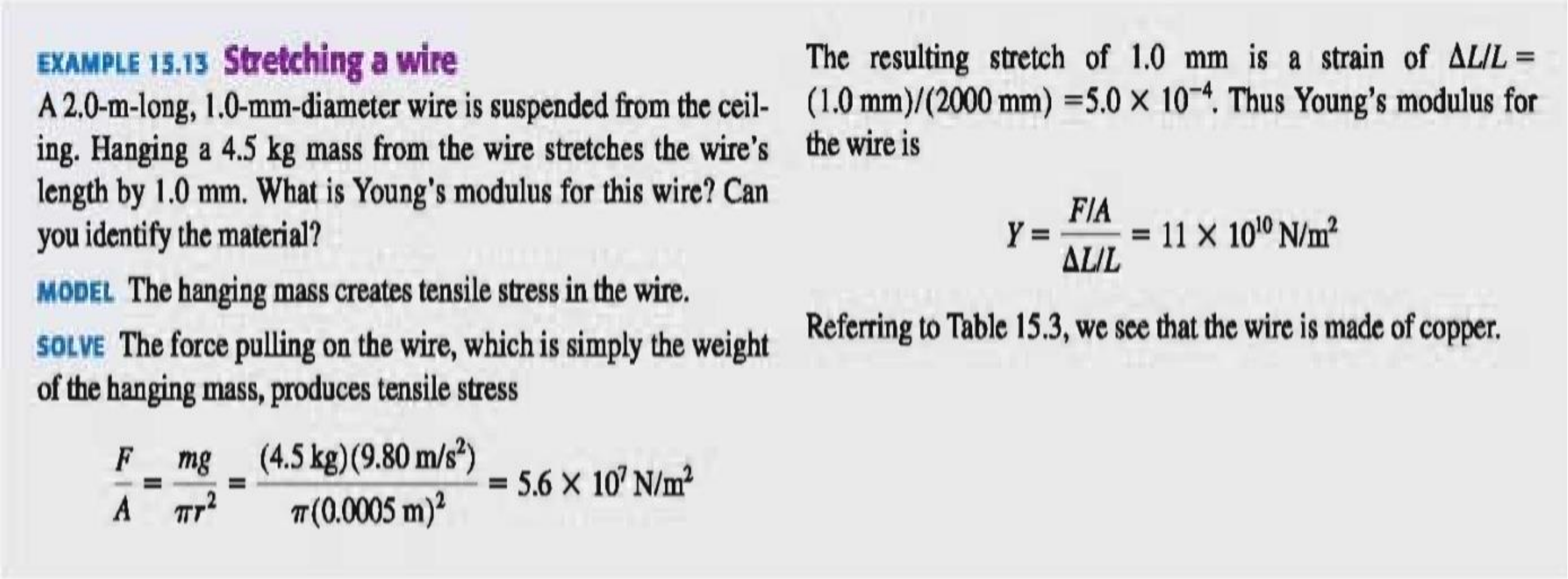
$$\downarrow$$

$$Y = \frac{kL}{A}$$

k = konstanta pegas dari batang



Sumber: *Randall, Physics for scientist and engineer*



EXAMPLE 15.13 **Stretching a wire**

A 2.0-m-long, 1.0-mm-diameter wire is suspended from the ceiling. Hanging a 4.5 kg mass from the wire stretches the wire's length by 1.0 mm. What is Young's modulus for this wire? Can you identify the material?

MODEL The hanging mass creates tensile stress in the wire.

SOLVE The force pulling on the wire, which is simply the weight of the hanging mass, produces tensile stress

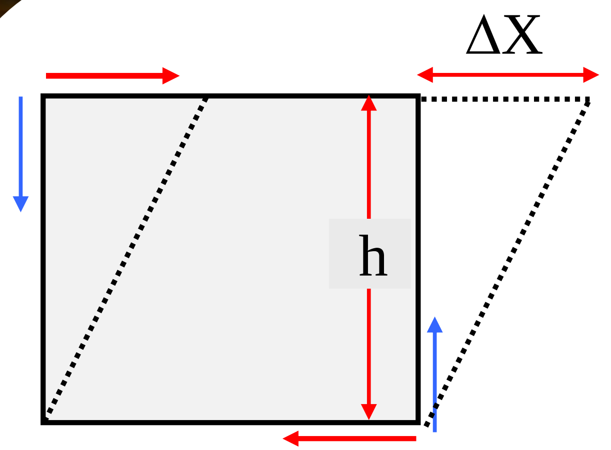
$$\frac{F}{A} = \frac{mg}{\pi r^2} = \frac{(4.5\text{ kg})(9.80\text{ m/s}^2)}{\pi(0.0005\text{ m})^2} = 5.6 \times 10^7\text{ N/m}^2$$

The resulting stretch of 1.0 mm is a strain of $\Delta L/L = (1.0\text{ mm})/(2000\text{ mm}) = 5.0 \times 10^{-4}$. Thus Young's modulus for the wire is

$$Y = \frac{F/A}{\Delta L/L} = 11 \times 10^{10}\text{ N/m}^2$$

Referring to Table 15.3, we see that the wire is made of copper.

Sumber: Randall: Physics for Scienties and Engineer



Tegangan Geser $= \dfrac{F_{//}}{A}$, $\boldsymbol{F} \parallel \boldsymbol{A}$

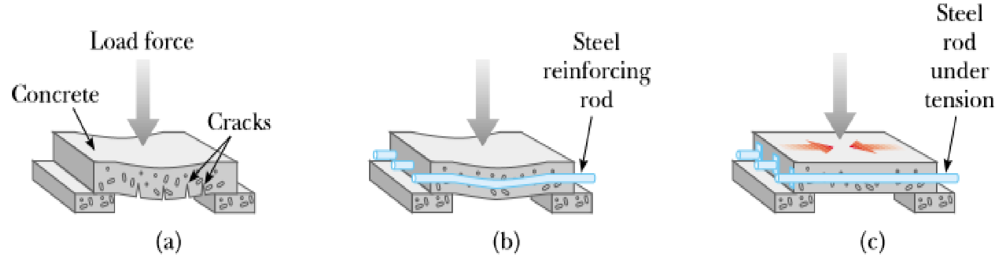
Tegangan = modulus elastisitas × Regangan

$$\frac{F_{//}}{A} = G\,\frac{\Delta X}{h}$$

Tegangan geser

Regangan geser

***G*: Modulus Geser**



Active Figure 12.18 (a) A concrete slab with no reinforcement tends to crack under a heavy load. (b) The strength of the concrete is increased by using steel reinforcement rods. (c) The concrete is further strengthened by prestressing it with steel rods under tension.

Dimensi sama dengan tegangan

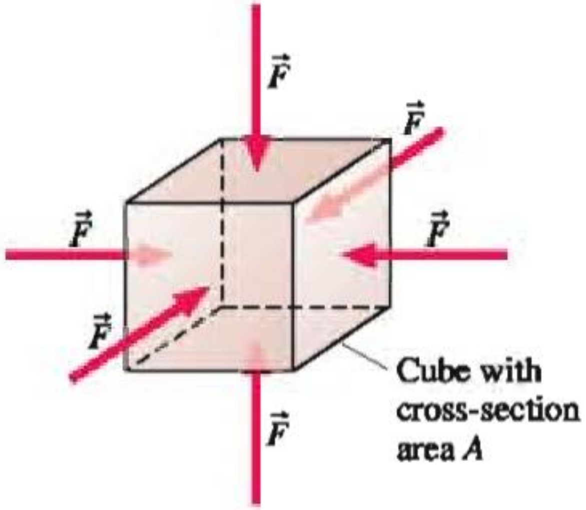
Modulus Bulk

Perbandingan (negatif) perubahan tekanan terhadap regangan volume yang dihasilkan

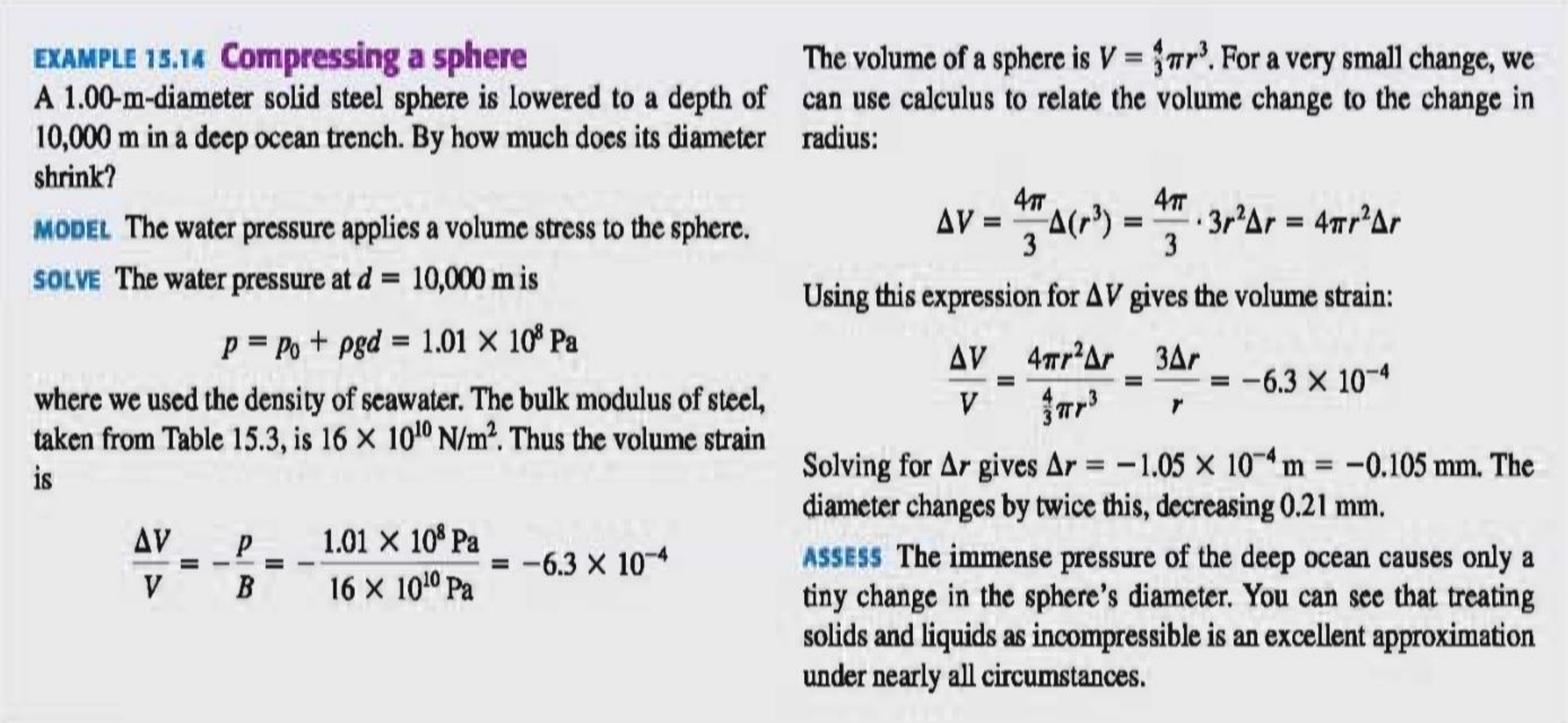
$$B = -\frac{\Delta P}{\Delta V/V}$$

Modulus kompresibilitas : K = 1/B

FIGURE 15.39 An object is compressed by pressure forces pushing equally on all sides.



Sumber: Serway, Physics for Scientiest and Engineer



EXAMPLE 15.14 **Compressing a sphere**

A 1.00-m-diameter solid steel sphere is lowered to a depth of 10,000 m in a deep ocean trench. By how much does its diameter shrink?

MODEL The water pressure applies a volume stress to the sphere.

SOLVE The water pressure at $d = 10{,}000$ m is

$$p = p_0 + \rho g d = 1.01 \times 10^8 \text{ Pa}$$

where we used the density of seawater. The bulk modulus of steel, taken from Table 15.3, is 16×10^{10} N/m^2. Thus the volume strain is

$$\frac{\Delta V}{V} = -\frac{p}{B} = -\frac{1.01 \times 10^8 \text{ Pa}}{16 \times 10^{10} \text{ Pa}} = -6.3 \times 10^{-4}$$

The volume of a sphere is $V = \frac{4}{3}\pi r^3$. For a very small change, we can use calculus to relate the volume change to the change in radius:

$$\Delta V = \frac{4\pi}{3}\Delta(r^3) = \frac{4\pi}{3} \cdot 3r^2\Delta r = 4\pi r^2 \Delta r$$

Using this expression for ΔV gives the volume strain:

$$\frac{\Delta V}{V} = \frac{4\pi r^2 \Delta r}{\frac{4}{3}\pi r^3} = \frac{3\Delta r}{r} = -6.3 \times 10^{-4}$$

Solving for Δr gives $\Delta r = -1.05 \times 10^{-4}$ m $= -0.105$ mm. The diameter changes by twice this, decreasing 0.21 mm.

ASSESS The immense pressure of the deep ocean causes only a tiny change in the sphere's diameter. You can see that treating solids and liquids as incompressible is an excellent approximation under nearly all circumstances.

Sumber: Randall, Physics for Scientists and Engineer

Terimakasih