Mastering Physics Prerequisites
Solving for an Unknown Value
Problems 11-15

11. A mass spectrometer is an instrument that identifies what ions are in a sample by heating them up and shooting them into a magnetic field at a speed of 20,000 m/sec. The lighter particles curve in tight circles and the heavier particles curve in larger circles.
When analyzing a tooth sample, the calcium ions curve in a circle of 4.2 centimeters.
a) Calcium has an atomic mass of 40.1 grams per mole, and a mole is 6.02×10^{23}. what is the mass of a single calcium atom?
b) A scientist needs to calibrate the magnetic field strength of the instrument and she determines that a doubly ionized calcium curves in a circle with a radius of 4.2 cm. The equation she develops is

$$(2 \times 1.60 \times 10^{-19}\ \text{C})(4.2\ \text{cm})B = m\ (20{,}000\ \text{m/sec})$$

where m is the mass of the ion. Solve this equation for the magnetic field B. Note that a

$$\frac{\text{N} \cdot \text{sec}}{\text{C} \cdot \text{m}}$$

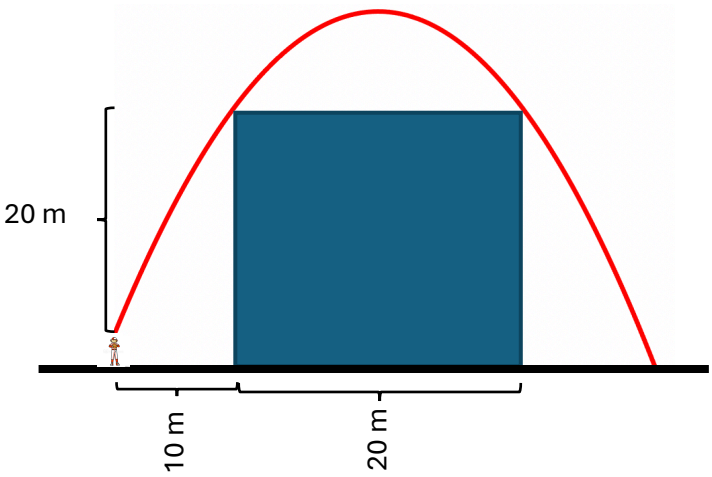
is a Tesla, which is a unit of magnetic field, and a N is a $\text{kg} \cdot \text{m/sec}^2$

12. When calculating the path differences for wave interference involving double-slit**s,** you often have to solve an equation such as

$$\sqrt{x^2 + (24\ \text{ft})^2} - 20\ \text{ft} = x$$

Solve this equation for x.

13. Dean is trying to determine the minimum speed a which he has to throw a baseball in order to get it over the dorm. He has two equations for the motion of the ball, which are given below.



$$20\text{ m} = \frac{1}{2}(-10\text{ m/sec}^2)t_{edge}^2 + v_{iy}t_{edge}$$

$$v_{iy} = (10\text{ m/sec}^2)2t_{edge}$$

There are two unknowns, v_{iy} and t_{edge}. Solve for each.

14. The track for the single luge contains numerous turns with very steep banks. These sleds can get up to 140 km/hr on the iced tracks. A physics student is trying to determine the forces on the luger when going through a turn of radius 30 meters that is banked at 60° when traveling at 140 km/hr. He comes up with the following two equations,

$$F_N \sin 30° - F_{fr} \sin 60° - 1000\text{ N} = 0$$

and

$$F_N \cos 30° + F_{fr} \cos 60° = 5041\text{ N}$$

Solve for both F_N and F_{fr}.

15. When solving for the forces on a car that is executing a turn on a banked road, a student has the following force equations – one from the horizontal direction and the other from the vertical direction.

$$F_N \sin 10° + F_{fr} \cos 10° = 5993\text{ N}$$

$$F_N \cos 10° = 15{,}000\text{ N} + F_{fr} \sin 10°$$

Solve for both F_N and F_{fr}.