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General Physics-I, Quiz 3
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St. ID:______________________, Name:_________________

1. On October 21, 2001, Ian Ashpole of the United Kingdom achieved a record altitude of 3.35 km (11 000 ft) powered by 600 toy balloons filled with helium. Each filled balloon had a radius of about 0.50 m and an estimated mass of 0.30 kg. (a) Estimate the total buoyant force on the 600 balloons. (b) Estimate the net upward force on all 600 balloons. (c) Ashpole parachuted to the Earth after the balloons began to burst at the high altitude and the buoyant force decreased. Why did the balloons burst?

Ans:

(a) We can estimate the total buoyant force of the 600 toy balloons as

$$B_{\text{total}} = 600 \cdot B_{\substack{\text{single}\\\text{balloon}}} = 600\left(\rho_{\text{air}} g V_{\text{balloon}}\right)$$
$$= 600\left[\rho_{\text{air}} g\left(\frac{4\pi}{3} r^3\right)\right]$$
$$= 600\left[\left(1.20\ \text{kg/m}^3\right)\left(9.80\ \text{m/s}^2\right)\frac{4\pi}{3}\left(0.50\ \text{m}\right)^3\right]$$
$$= 3.7 \times 10^3\ \text{N} = \boxed{3.7\ \text{kN}}$$

(b) We estimate the net upward force by applying Newton's second law in the vertical direction:

$$\sum F_y = B_{\text{total}} - m_{\text{total}} g$$
$$= 3.7 \times 10^3\ \text{N} - 600\left(0.30\ \text{kg}\right)\left(9.8\ \text{m/s}^2\right)$$
$$= 1.9 \times 10^3\ \text{N} = \boxed{1.9\ \text{kN}}$$

This net force was sufficient to lift Ashpole, his parachute, and other supplies.

(c) Atmospheric pressure at this high altitude is much lower than at Earth's surface, so the balloons expanded and eventually burst.

2. A 2.00-kg object attached to a spring moves without friction (b= 0) and is driven by an external force given by the expression F = 3.00 sin (2πt), where F is in newtons and t is in seconds. The force constant of the spring is 20.0 N/m. Find (a) the resonance angular frequency of the system, (b) the angular frequency of the driven system, and (c) the amplitude of the motion.

Ans: We are given $F = 3.00 \sin(2\pi t)$, $k = 20.0$ N/m, and $m = 2.00$ kg.

(a) $$\omega_0 = \sqrt{\frac{k}{m}} = \sqrt{\frac{20.0\ \text{N/m}}{2.00\ \text{kg}}} = \boxed{3.16\ \text{s}^{-1}}$$

(b) From $F = 3.00 \sin(2\pi t)$, the angular frequency of the force is

$$\omega = 2\pi = \boxed{6.28\ \text{s}^{-1}}$$

(c) From equation 15.36, the amplitude A of a driven oscillator, with $b = 0$, gives

$$A = \frac{F_0 / m}{\omega^2 - \omega_0^2} = \frac{(3.00\ \text{N/m})/(2.00\ \text{kg})}{(6.28\ \text{s}^{-1})^2 - (3.16\ \text{s}^{-1})^2} = 0.050\ 9\ \text{m} = \boxed{5.09\ \text{cm}}$$