1.   A black hole is defined to be an object from which the escape velocity exceeds c, the speed of light. At what distance from a 5 $M_\odot$ star would the escape velocity equal c?

    A) 7.4×10^{-30} km C) 2100 km
    B) 15 km   D) 1.5×10^{8} km

2.   What is the tension in a cable holding a 1500-kg cannon above the floor of the ocean?   The cannon displaces 0.20 m³, and seawater has a density of 1025 kg/m³.

    A) 2 kN   C) 15 kN
    B) 13 kN   D) 17 kN

Useful equations and constants:

$$U = -\,GMm/r \qquad K = \tfrac{1}{2}\,m\,v^2$$
$$v_e = (2GM/R)^{1/2} \qquad T^2 = (4\pi^2/G)\,a^3/(m_1 + m_2)$$
$$\Delta P = \rho\,g\,h \qquad F_b = \rho_d\,V_d\,g$$
$$g = 9.80 \text{ m/s}^2 \qquad G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$$
$$c = 3.00 \times 10^{8} \text{ m/s} \qquad 1\,M_\odot = 1.99 \times 10^{30} \text{ kg}$$
$$1 \text{ yr} = 3.156 \times 10^{7} \text{ s} \qquad 1 \text{ AU} = 1.496 \times 10^{11} \text{ m}$$

1. A binary star system consists of two stars separated by a mean distance of 32 AU. If they take 165 years to complete one orbit, what is the combined mass of the two stars?

    A) 3.6×10^{-19} $M_\odot$ C) 2.3×10^{-4} $M_\odot$
    B) 2.0×10^{-12} $M_\odot$ D) 1.2 $M_\odot$

2. A U-shaped tube is partially filled with water (ρ=1000 kg/m^3), and then someone adds 8.0 cm of oil (750 kg/m^3) to one side. How far above the level of the oil-water interface does the water rise on the other side?

    A) 2.0 cm   C) 8.0 cm
    B) 6.0 cm   D) 10.7 cm

Useful equations and constants:

$U = -\,GMm/r$ $K = \tfrac{1}{2}\,m\,v^2$
$v_e = (2\,GM/R)^{1/2}$ $T^2 = (4\pi^2/G)\,a^3/(m_1 + m_2)$
$\Delta P = \rho\,g\,h$ $F_b = \rho_d\,V_d\,g$
$g = 9.80$ m/s^2 $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
$c = 3.00 \times 10^8$ m/s   1 $M_\odot = 1.99 \times 10^{30}$ kg
1 yr $= 3.156 \times 10^7$ s   1 AU $= 1.496 \times 10^{11}$ m

1. Io has a radius of 1815 km. If the escape velocity from its surface is 2.56 km/s, what is its mass?

   A) 9.0×10^{13} kg   C) 8.9×10^{22} kg
   B) 4.5×10^{22} kg   D) 1.8×10^{23} kg

2. A block of balsa wood is observed to float in water (ρ=1000 kg/m^3) with only 15% of its mass submerged. What is its density?

   A) 150 kg/m^3 C) 850 kg/m^3
   B) 670 kg/m^3 D) 6700 kg/m^3

Useful equations and constants:

$U = -\ GMm/r$

$v_e = (2GM/R)^{1/2}$

$\Delta P = \rho\ g\ h$

$g = 9.80$ m/s^2

$c = 3.00 \times 10^8$ m/s

1 yr $= 3.156 \times 10^7$ s

$K = \frac{1}{2}\ m\ v^2$

$T^2 = (4\pi^2/G)\ a^3/(m_1 + m_2)$

$F_b = \rho_d\ V_d\ g$

$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}

1 M$_\odot = 1.99 \times 10^{30}$ kg

1 AU $= 1.496 \times 10^{11}$ m