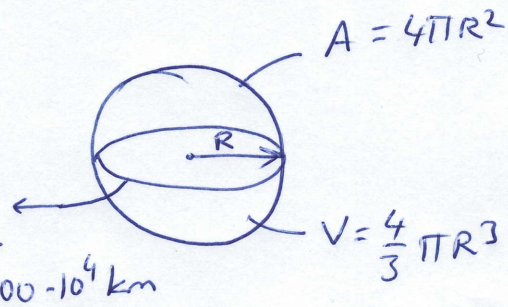
Mechanics I - Question Bank 1

2018-2019

Full Name: KEY

1- Earth is approximately a sphere of radius 6.37×10^6 m. What are
(a) its circumference in kilometers,
(b) its surface area in square kilometers, and
(c) its volume in cubic kilometers?



$C = 2 \times 3.14 \times 6.37 \times 10^3 = 40.0036 \times 10^3$ km $\simeq 4.00 \cdot 10^4$ km

$R = 6.37 \times 10^6$ m $= 6.37 \times 10^3$ km

$A = 4\pi R^2 = 4 \times 3.14 \times (6.37 \times 10^3)^2 = 509.65 \times 10^6$ km^2

$V = \frac{4}{3}\pi R^3 = \frac{4}{3} \times 3.14 \times (6.37 \times 10^3)^3 = 1082.15 \times 10^9$ km^3

2- The fastest growing plant on record is a *Hesperoyucca whipplei* that grew 3.7 m in 14 days. What was its growth rate in micrometers per second?

We should find the growth rate in μm/s.

Growth rate: $h = 3,7$ m $= 3.7 \times 10^3$ mm $= 3.7 \times 10^3 \times 10^3$ μm $= 3,7 \times 10^6$ μm

$t = 14 \text{ days} \times \frac{24 \text{ h}}{1 \text{ day}} \times \frac{60 \text{ min}}{1 \text{ h}} \times \frac{60 \text{ s}}{1 \text{ min}} = 1209600$ s

Growth rate: $\frac{h}{t} = \frac{3.7 \times 10^6 \text{ μm}}{1209600 \text{ s}} = 3,1$ μm/s

3- Consider the following equation: $x = At^2 + \frac{B}{(v+\alpha)}t$, where x is the distance, t is the time and v is the speed. Find the dimensions of B:

$x = At^2 + \frac{B}{(V+\alpha)} \cdot t$

$\downarrow$

$L = L$

$At^2 = L$

$A \cdot T^2 = L$

$A = \frac{L}{T^2}$

$\frac{B}{(V+\alpha)} \cdot t = L \Rightarrow \frac{B}{\frac{L}{T}} \cdot T = L$

$V = \frac{L}{T}$

$B = \frac{L^2}{T^2}$

4- The volume V of an object as a function of time is calculated by $V = \frac{A}{B}t^4 + Bt$, where t is measured in seconds and V is in cubic meters. Determine the dimension of the constant A.

$V \rightarrow$ Volume $= L^3$

$V = \frac{A}{B}t^4 + Bt$

$\downarrow$

$L^3 = L^3$

$\frac{A}{B}t^4 = L^3$

$Bt = L^3$

$BT = L^3$

$B = \frac{L^3}{T}$

$\frac{A}{B}T^4 = L^3$

$\frac{A}{\frac{L^3}{T}} \cdot T^4 = L^3$

$A = \frac{L^6}{T^5}$

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5- The position x of a particle is given by $x = Rt^3 + \frac{H}{R}t^2$, where x is in meters and t is in seconds.

Determine the dimension of H.

$X = Rt^3 + \frac{H}{R}t^2$

$L = L$

$Rt^3 = L \quad R\,T^3 = L \quad R = \frac{L}{T^3}$

$\frac{H}{R}t^2 = L \quad \frac{H}{\frac{L}{T^3}}T^2 = L \quad H = \frac{L^2}{T^5}$

6- What is the dimension of the constant G in the equation: $F = G\frac{m_1 m_2}{r^2}$, where F is force, m_1 and m_2 are masses and r is the distance between the two masses.

$F = ma = kg\,\frac{M}{s^2} \rightarrow F = M\frac{L}{T^2}$ ← Dimensions of force

$F = G\frac{M_1 M_2}{R^2}$

$M\frac{L}{T^2} = G\frac{MM}{L^2} \Rightarrow G = \frac{L^3}{MT^2}$

7- The speed v in m/s of an automobile is given by $v = at^3 + bt^2$, where the time t is in seconds.

Determine the dimensions of a and b.

$v = at^3 + bt^2$

$v = \frac{m}{s} \rightarrow \frac{L}{T}$

$\frac{L}{T} = \frac{L}{T}$

$bt^2 = \frac{L}{T} \quad bT^2 = \frac{L}{T} \quad b = \frac{L}{T^3}$

$at^3 = \frac{L}{T} \Rightarrow aT^3 = \frac{L}{T} \quad a = \frac{L}{T^4}$

8- Copper has a density of 8.96 g/cm^3, and the mass of a copper atom is 1.06 x10^{-25} kg. If the atoms are spherical and tightly packed, what is the radius of a copper atom?

According to given conditions, we assume that the density of a copper atom is 8.96 g/cm^3. $m = 1.06\times10^{-25}\,kg = 1.06\times10^{-22}\,g$

$d = \frac{m}{V} \Rightarrow V = \frac{m}{d} = \frac{1.06\times10^{-22}\,g}{8.96\,g/cm^3} = 0.12\times10^{-22}\,cm^3$

$V = \frac{4}{3}\pi R^3 \quad 0.12\times10^{-22} = \frac{4}{3}\,3.14\,R^3 \quad R^3 = 0.029\times10^{-22}$

$R^3 = 2.90\times10^{-18}\,cm^3$

$R = 6.62\times10^{-6}\,cm$