Phy 101

Chapter 1

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Q17.

The speed of an automobile is given by $v = a\,b\,t^2 + b\,t^3$, where the time t is in seconds and a and b are constants. The dimension of a is

A) T
B) L
C) $\frac{L}{T}$
D) $\frac{T}{L}$
E) LT

191, Major 1, Q17

Ans:

bt^3 has dimension of velocity: $\frac{L}{T} \Rightarrow$ dimension of B is $\frac{L}{T^4}$

abt^2 has dimension of velocity: $\frac{L}{T}$ then the dimension of a should be: T

Q1.

A position of a particle at time t is given by: $x = ab(1 - e^{-bt})$. The dimensions of a and b are, respectively:

A) LT and T^{-1}
B) LT^{-1} and L
C) LT^{-1} and LT^{-1}
D) T^{-1} and LT^{-1}
E) MT^{-1} and LT^{-1}

Ans:

$$bT = 1$$

$$b = T^{-1}$$

$$ab = L \Rightarrow a = \frac{L}{b} = LT$$

182, Major 1, Q1

Q2.

A uniform solid cylinder with a radius of 2.30 cm and a height of 55.0 inches has a mass of 690 g. Find its density. (1 inch = 2.54 cm)

A) 297 kg/m^3
B) 230 kg/m^3
C) 145 kg/m^3
D) 400 kg/m^3
E) 520 kg/m^3

Ans:

$$\rho = \frac{m}{\pi R^2 h} = \frac{690\ g \times \frac{1\ kg}{1000\ g}}{3.14 \times (2.3)^2 cm^2 \times \frac{1\ m^2}{(100)^2 cm^2} \times 55\ in \times \frac{2.54\ cm}{1\ in} \times \frac{1\ m}{100\ cm}}$$

$$\Rightarrow \rho = 297\ kg/m^3$$

182, Major 1, Q2

Q1.

Assume the equation $x = At^3 + Bt$ describes the motion of a particular object, with x having the dimension of length and t having the dimension of time. Determine the dimensions of the constants A and B respectively.

A) M^0L/T^3, M^0L/T
B) M^0L/T^2, M^0L/T^2
C) ML/T^3, ML/T
D) M^0L/T, M^0L/T
E) ML/T, ML/T

Ans:

$$[A] = \left[\frac{x}{t^3}\right] = M^0\, L/T^3\,; [B] = \left[\frac{x}{t}\right] M^0\, L/T$$

181, Major 1, Q1

Q2.

Gold, which has a density of 19.32 g/cm^3, can be pressed into a thin leaf. If gold with a mass of 27.63 g, is pressed into a leaf of 1.000 µm thickness, what is the area of the leaf?

A) 1.430 m^2
B) 0.545 m^2
C) 1.115 m^2
D) 0.755 m^2
E) 1.945 m^2

Ans:

$$m = \rho \times V = \rho \times (A \times t) \Rightarrow A = \frac{m}{\rho \times t}$$

$$m = 27.63\ g = 27.63 \times 10^{-3} kg$$

$$\rho = 19.32\ g/cm^3 = 19.32 \times 10^3\ kg/m^3$$

$$t = 10^{-6}\ m$$

$$A = \frac{27.63 \times 10^{-3}}{19.32 \times 10^3 \times 10^{-6}} = \frac{27.63}{19.32} = 1.430\ m^2$$

181, Major 1, Q2

Q1.

The speed of an object is given by: $v = \sqrt{\frac{B}{\rho}}$, where ρ is the density of the object, and *B* is a constant. What are the dimensions of *B*?

A) $ML^{-1}T^{-2}$
B) $ML^{-2}T^{-1}$
C) $M^{-1}L^{-1}T^{-2}$
D) $M^{-1}L^{-2}T^{-1}$
E) TM^2

Ans:

$$v^2 = \frac{B}{\rho} \Rightarrow B = \rho v^2 = \frac{kg}{m^3} \cdot \frac{m^2}{s^2} = \frac{kg}{ms^2}$$

$$[B] = ML^{-1}T^{-2}$$

173, Major 1, Q1

Q2.

A car is driving at 70 miles/hour. Express this speed in (m/s). (1 mile = 5280 ft, and 1m = 3.3 ft)

A) 31
B) 47
C) 14
D) 28
E) 56

Ans:

$$v = 70\,\frac{mi}{h} \cdot \frac{1\,h}{3600\,s} \cdot \frac{5280\,ft}{1\,mi} \cdot \frac{1\,m}{3.3\,ft} = 32\text{ m/s}$$

173, Major 1, Q2

Q1.

Work is defined as the scalar product of force and displacement. Power is defined as the rate of change of work with time. The dimension of power is:

A) ML^2T^{-3}
B) $M^2L^2T^3$
C) $ML^{-1}T^{-2}$
D) $M^2L^2T^2$
E) $ML^{-1}T^{-1}$

Ans:

$$P = \frac{W}{t} = \frac{F\Delta X}{t} = \frac{ML}{T^2}\frac{L}{T} = ML^2T^{-3}$$

172, Major 1, Q1

Q1.

The magnitude of a force applied on an object is given by the relation: $F = k\rho^x v^y t^z$, where k is dimensionless constant, ρ is density, v is speed and t is time. The values of x, y and z; respectively; are:

A) 1, 4 and 2
B) 1, 2 and 3
C) 2, 1 and 2
D) 1, 2 and 4
E) 1, 4 and 3

Solution

$$\vec{F} = kP^x v^y t^z$$

$$MLT^{-2} = (ML^{-3})^x (LT^{-1})^y T^z$$

$$MLT^{-2} = M^x L^{-3x+y} T^{-y+z}$$

$$x = 1$$

$$-3x + y = 1 \qquad \Rightarrow y = 4$$

$$-y + z = -2 \qquad \Rightarrow z = 2$$

171, Major 1, Q1

Q1.

When a large object moves in air, there is a resistive force on it whose magnitude is given by: $F = 0.5\, D\, \rho\, B\, v^2$, where D is a dimensionless constant, ρ is the density of the air and v is the speed of the object. What are the dimensions of B?

A) L^2
B) M^2
C) T^2
D) ML^2
E) TM^2

Ans: $$[B] = \left[\frac{F}{\rho v^2}\right] = \left(kg \cdot \frac{m}{s^2}\right) \cdot \left(\frac{kg}{m^3}\right)^{-1} \cdot \left(\frac{m^2}{s^2}\right)^{-1}$$

$$= \frac{\cancel{kg} \cdot m}{\cancel{s^2}} \cdot \frac{m^3}{\cancel{kg}} \cdot \frac{\cancel{s^2}}{m^2} = m^2 \rightarrow L^2$$

163, Major 1, Q1

Q2.

A cubic box has a side of length 1.00 ft. What is the volume of the box in cubic meters? (1 ft = 12.0 inch, 1 inch = 2.54 cm)

A) 0.0283
B) 0.843
C) 0.759
D) 0.227
E) 0.00100

Ans:

$$l = 1\cancel{ft} \cdot \frac{12\ \cancel{in}}{1\ \cancel{ft}} \cdot \frac{2.54\ cm}{1\ \cancel{in}} \cdot \frac{1\ m}{100\ cm} = 0.3048\ m$$

$$V = l^3 = (0.3048)^3 = 0.0283\ m^3$$

163, Major 1, Q2

Q1.

The velocity of a particle is time dependent and is given by the equation: $v = At^2 + \frac{B}{A}$. Where, *t* is time and *A* and *B* are unknown quantities. Find the dimension of *B*.

A) L^2/T^4
B) T/L
C) T^3/L^3
D) L/T^4
E) L^2T^2

Ans:

$$At^2 = v \Rightarrow At^2 = \frac{L}{T} \Rightarrow A = \frac{L}{T^3}$$

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

$$\therefore B = \frac{L^2}{T^4}$$

162, Major 1, Q1

Q1.

Van der Wall's equation of state for gases is given by

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

Where, *P* is the pressure (kg/m.s^2), *V* is the volume (m^3) and *T* is the temperature (K). *a*, *b* and *R* are constants. The dimension of "*a*" is

A) ML^5T^{-2}
B) L^2T^{-2}
C) L^6
D) $ML^{-1}T^{-2}$
E) ML^2T^{-2}

Ans:

$$\frac{[a]}{[v^2]} = [P]$$

$$[a] = ML^{-1}T^{-2}L^6 = ML^5T^{-2}$$

161, Major 1, Q1

Q1.

The air resistance force on a falling object can be expressed as $\boldsymbol{F} = \boldsymbol{a}\, \boldsymbol{v}^2$, where $\boldsymbol{a}$ is a constant, and $\boldsymbol{v}$ is the speed of the object. The dimension of $\boldsymbol{a}$ is

A) M/L
B) ML
C) L/M
D) M/L^2
E) ML^2

Answer:

$$a = \frac{F}{v^2} = kg.\frac{m}{s^2}\frac{s^2}{m^2} = \frac{kg}{m} \rightarrow ML^{-1}$$

153, Major 1, Q1

Q2.

Assume it takes 6.00 minutes to fill a 30.0-gallon tank. Calculate the rate at which the tank is filled in cubic meters per second. [1 gallon = 231 $inch^3$, 1 inch = 2.54 cm]

A) 3.15×10^{-4}
B) 4.89×10^{-5}
C) 5.25×10^{-5}
D) 1.89×10^{-2}
E) 1.05×10^{-5}

Answer:

$$V = 30\ gal\frac{231\ in^3}{1\ gal} = \frac{(2.54)^3 cm^3}{1\ in^3}\cdot\ \frac{1\ m^3}{10^6\ cm^3} = 0.11356\ m^3$$

$$rate = \frac{V}{t} = \frac{0.11356}{360} = 3.15\times\ 10^{-4}$$

153, Major 1, Q2

Q1.

The density of water is 1.0 g/cm^3. If 1.0 kg of water is used to completely fill a perfectly spherical container, find the radius of the container.

A) 6.2 cm
B) 8.5 cm
C) 3.1 cm
D) 4.3 cm
E) 8.9 cm

Ans:

$$V_{sphere} = \frac{4}{3}\pi r^3 = \frac{m}{\rho_{H_2O}} = \frac{1}{10^3}$$

$$\Rightarrow r = 0.062 \text{ m} = 6.2 \text{ cm}$$

152, Major 1, Q1

Q2.

If the acceleration a (in m/s^2) of a car is given by $a(t) = c\,t^2 + d\,t^4$, where the time t is in seconds and c and d are constants. The SI units of c and d are respectively:

A) m/s^4; m/s^6
B) m/s^2; m/s^4
C) m/s^4; m/s^2
D) ms^6 ; ms^2
E) ms^2 ; m/s^6

Ans:

$$[a] = \frac{m}{s^2} = cs^2 \Rightarrow [C] = LT^{-4}$$

$$[a] = \frac{L}{T^2} = dT^4 \Rightarrow [d] = LT^{-6}$$

152, Major 1, Q2

Q1.

The body mass index (BMI) of a person is calculated in SI units using the formula:

$$BMI = weight\ (kg) / height^2\ (m^2)$$

Find the BMI of a person (in SI units) whose weight is 160 lb (pound) and height is 70.0 inches. (1.00 inch = 2.54 cm, 1.00 lb = 454 g).

A) 23.0
B) 16.7
C) 5.45
D) 35.0
E) 45.2

Ans:

$$BMI = \frac{(160 \times 0.454)}{(70 \times 2.54 \times 10^{-2})^2} = 22.98$$

151, Major 1, Q1

Q2.

It is observed that the frequency f (s^{-1}) of oscillations of a string depends upon its mass (M), length (L) and tension P ($kg.m/s^2$) as follows:

$$f = C\, P^a M^b L^c$$

where C is a dimensionless constant. Find the values of the constants a, b, and c (in this order)

A) ½, -½, -½
B) ½, ½, -½
C) -½, ½, ½
D) ½, -½, ½
E) -½, -½, ½

Ans:

$[f] = [P]^a\,[m]^b\,[l]^c \rightarrow T^{-1} = M^a L^a T^{-2a} M^b L^c$

$\Rightarrow -2a = -1,\ a + b = 0,\ a + c = 0$

$\rightarrow a = -1/2,\ b = ½,\ c = 1/2$

151, Major 1, Q2
