**Q1.**

The magnitude of the resistive force $\boldsymbol{F}$ acting on a falling object in air is given by

$F = bv^2$, where $v$ is the speed of the falling object. What is the dimension of $b$?

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

**Ans:**

$$F = bv^2$$

$$MLT^{-2} = [b]L^2T^{-2}$$

$$[b] = ML^{-1}$$

---

**Q2.**

The density of iron is $7.90\times10^3$ $kg/m^3$. What is the mass of a spherical iron ball having a volume of $122\ in^3$ $(1\ in = 2.54\ cm)$.

A) 15.8 $kg$
B) 12.5 $kg$
C) 25.4 $kg$
D) 79.0 $kg$
E) 12.2 $kg$

**Ans:**

$$M = \rho \times V$$

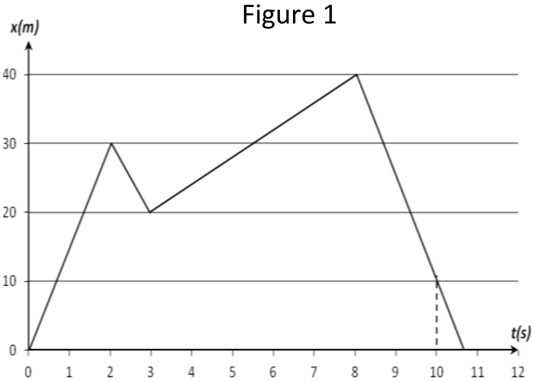
$$M = 7.90 \times 10^3\ \frac{kg}{m^3} \times 122\ \left(1\ in \times \frac{2.54\ cm}{1\ in} \times \frac{0.01\ m}{1\ cm}\right)^3 = 15.8\ kg$$

---

**Q3.**

A particle is moving back and forth along the x-axis. A graph of its position versus time is given in Figure 1. What is the average speed of the particle between t = 0 and t = 10 s?

Figure 1




A) 9 m/s
B) 8 m/s
C) 7 m/s
D) 6 m/s
E) 5 m/s

**Ans:**

$$v = \left(\frac{30 + 10 + 20 + 30}{10}\right) m/s = 9\ m/s$$

---

**Q4.**

A rocket accelerates vertically up from ground level from rest at 30 m/s$^2$ for 30 s; then runs out of fuel. What is the rocket's final altitude? (Ignore air resistance)

A) 55 km
B) 45 km
C) 35 km
D) 25 km
E) 15 km

**Ans:**

$$h_1 = \frac{1}{2} a \times t_1^2$$

$$v_1 = a \times t_1$$

$$v_1^2 = 2g \times h_2 \rightarrow h_2 = \frac{v_1^2}{2g}$$

$$h = h_1 + h_2 = \frac{1}{2} \times 30 \times 30^2 + \frac{(30 \times 30)^2}{2 \times 9.8} = 55\ km$$

---

**Q5.**

The position of a particle moving along the $x$-axis is given by $x(t) = 3t^3 - 9t^2 + 18$, where $x$ is in meters and $t$ is in seconds. What is the value of $x$ when the particle's acceleration is zero?

A) 12 m
B) 10 m
C) 19 m
D) 20 m
E) 15 m

**Ans:**

$$x(t) = 3t^3 - 9t^2 + 18$$

$$\frac{dx}{dt} = 9t^2 - 18t$$

$$\frac{d^2x}{dt^2} = 18t - 18 = 0 \; at \; t = 1 \; s$$

$$x(t = 1s) = (3 - 9 + 18)m = 12 \; m$$

---

**Q6.**

A time $t$ = 0 an object is fired vertically up with an initial speed $v_o$. It takes the object 10 s to return back to its starting point. What is its initial speed $v_o$ ? (Ignore air resistance)

A) 49 m/s
B) 98 m/s
C) 25 m/s
D) 10 m/s
E) 55 m/s

**Ans:**

$$v(t) = v_0 - gt$$

$$At \; t = 10 \; s, -v_0 = v_0 - gt \rightarrow v_0 = \frac{gt}{2} = \frac{9.8 \times 10}{2} = 49 \; m/s$$

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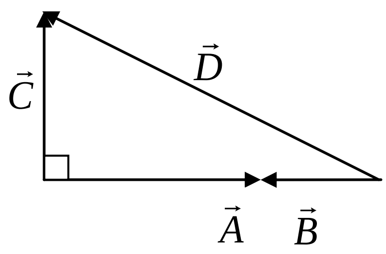
**Q7.**

Refer to **Figure 2**. Express vector $\vec{A}$ in terms of vectors $\vec{B}$, $\vec{C}$, and $\vec{D}$.

Figure 2




A) $\vec{A}=\vec{B}+\vec{C}-\vec{D}$
B) $\vec{A}=\vec{B}+\vec{C}+\vec{D}$
C) $\vec{A}=\vec{B}-\vec{C}-\vec{D}$
D) $\vec{A}=\vec{B}-\vec{C}+\vec{D}$
E) $\vec{A}=-\vec{B}+\vec{C}-\vec{D}$

**Ans:**

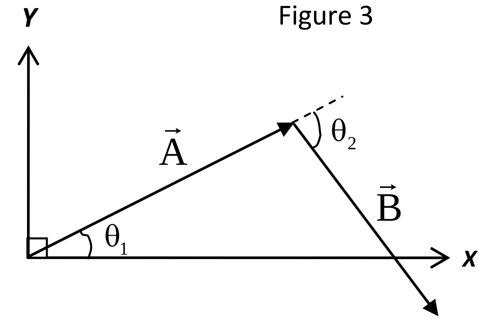
$From\ the\ figure: \vec{C} = \vec{A} - \vec{B} + \vec{D} \rightarrow \vec{A} = \vec{B} + \vec{C} - \vec{D}$

---

**Q8.**

The two vectors $\vec{A}$ and $\vec{B}$ in **Figure 3** have equal magnitudes of 10 m and the angle $\theta_1 = 30^\circ$ and $\theta_2 = 70^\circ$. What is the *y* component of the resultant vector $\vec{A}+\vec{B}$?

Figure 3




A) −1.43 m
B) −2.86 m
C) +2.50 m
D) −5.00 m
E) −5.50 m

**Ans:**

$A_y = A \times sin(\theta_1) = 10 \times sin(30^o) m = 5\ m$

$B_y = -A \times cos(180^o - \theta_2) = -10 \times cos(50^o) - -6.43\ m$

$A_y + B_y = -1.43\ m$

---

**Q9.**

What is the angle that vector $\vec{A} = -3\hat{i} - 4\hat{j}$ makes with the positive *x*–axis?

A) 127°
B) 147°
C) 137°
D) 133°
E) 90°

**Ans:**

$$\theta = -\left(180^o - tan^{-1}\left(\frac{-4}{-3}\right)\right) = -127^o$$

---

**Q10.**

Vector $\vec{A}$ has an *x* component of 3.0 m and a *y* component of $-5.0$ m, vector $\vec{B}$ has an *x* component of $-4.0$ m and a *y* component of 8 m. What are the magnitude of $\vec{A} \times \vec{B}$ and the angle it makes with the *xy* plane?

A) 4 $m^2$; 90°
B) 5 $m^2$; 90°
C) 4 $m^2$; 45°
D) 4 $m^2$; 180°
E) 6 $m^2$; 90°

**Ans:**

$$\vec{A} = 3\hat{\imath} - 5\hat{\jmath}$$

$$\vec{B} = -4\hat{\imath} + 8\hat{\jmath}$$

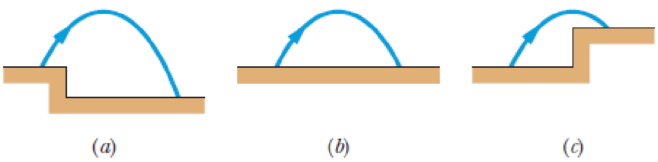
$$\vec{A} \times \vec{B} = (3\hat{\imath} - 5\hat{\jmath}) \times (-4\hat{\imath} + 8\hat{\jmath}) = 4\hat{k}$$

---

**Q11.**

**Figure 4** shows three situations in which identical projectiles are launched (at the same level) at identical initial speeds and angles. The projectiles do not land on the same surface, however. Rank the situations according to the final speeds of the projectiles just before they land, greatest first.

Figure 4




A) a; b; c
B) a; c; b
C) b; a; c
D) b; c; a
E) c; a; b

**Ans:**

A

---

**Q12.**

A particle's position vector is initially $\vec{r} = 10.0\hat{i} - 12.0\hat{j} + 4.0\hat{k}$, and 10 s later it is $\vec{r} = -4.0\hat{i} + 16.0\hat{j} - 4.0\hat{k}$, all in meters. In unit vector notation, what is its $\vec{v}_{avg}$ during the10 s?

A) $-1.4\hat{i} + 2.8\hat{j} - 0.8\hat{k}$
B) $+1.4\hat{i} + 2.8\hat{j} - 0.8\hat{k}$
C) $-1.4\hat{i} - 2.8\hat{j} - 0.8\hat{k}$
D) $-1.4\hat{i} + 2.8\hat{j} + 0.8\hat{k}$
E) $+1.4\hat{i} - 2.8\hat{j} + 0.8\hat{k}$

**Ans:**

$\vec{r}_1 = 10\hat{\imath} - 12\hat{\jmath} + 4\hat{k}$

$\vec{r}_2 = -4\hat{\imath} + 12\hat{\jmath} - 4\hat{k}$

$\Delta\vec{r} = \vec{r}_2 - \vec{r}_1 = -14\hat{\imath} + 28\hat{\jmath} - 8\hat{k}$

$\Delta t = 10\ s, \vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t} = -1.4\hat{\imath} + 2.8\hat{\jmath} - 0.8\hat{k}$

---

**Q13.**

A small ball rolls horizontally off the edge of a tabletop that is 2.40 m high. It strikes the flour at point 3.00 m horizontally from the table edge. How long is the ball in the air?

A) 0.700 s

B) 0.500 s

C) 0.600 s

D) 0.400 s

E) 0.800 s

**Ans:**

$$y = h - \frac{1}{2} g \times t^2 \rightarrow y = 0 \; at \; t = \sqrt{\frac{2 \times h}{g}} = \sqrt{\frac{2 \times 2.40 \, m}{9.8 \frac{m}{s^2}}} = 0.700 \, s$$

---

**Q14.**

A student runs as fast as he can along a moving sidewalk in 2.50 s. He then turns around and runs as fast as he can back along the moving sidewalk to his starting point, taking 10 s. What is the ratio of the student's running speed to the sidewalk's speed?

A) 1.67

B) 1.25

C) 1.27

D) 1.17

E) 1.34

**Ans:**

$$t_1 = \frac{d}{v + V} = 2.5 \, s$$

$$t_2 = \frac{d}{v - V} = 10 \, s$$

$$\frac{t_2}{t_1} = 4 = \frac{v + V}{v - V} \rightarrow \frac{v}{V} = \frac{5}{3} = 1.67$$

---

**Q15.**

**Figure 5** shows four blocks being pulled across a frictionless floor by force $\vec{F}$. Rank the cords according to their tension, greatest first.

A) cord 3; cord 2; cord 1

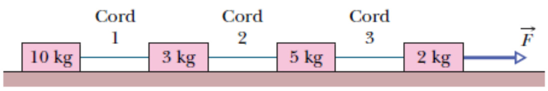
B) cord 2; cord 3; cord 1

C) cord 1; cord 2; cord 3

D) cord 3; cord 1; cord 2

E) all cords tie

Figure 5




**Ans:**

A

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**Q16.**

An elevator cab and its load have a combined mass of 2000 *kg*. Find the tension in the supporting cable when the cab, originally moving downward at10 m/s, is brought to rest with constant acceleration in a distance of 50 m.

A) $2.2\times10^4$ N

B) $3.2\times10^4$ N

C) $4.2\times10^4$ N

D) $2.5\times10^2$ N

E) $7.3\times10^3$ N

**Ans:**

$$v_f^2 - v_i^2 = -2a \times d \rightarrow 0 - (-100)^2 \frac{m^2}{s^2} = -2 \times a \times 50\, m \rightarrow a = +1\, m/s^2$$

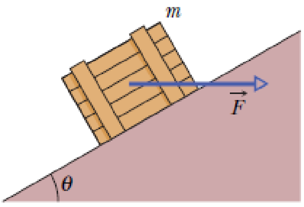
$$T - mg = ma \rightarrow T = m \times (g + a) = 2000 \times 10.8\, N = 2.2 \times 10^4\, N$$

---

**Q17.**

In **Figure 6**, a crate of mass m = 150 *kg* is pushed at constant speed up a frictionless ramp ($\theta = 30.0^{\circ}$) by a horizontal force $\vec{F}$ . What is the magnitude of the force on the crate from the ramp?

Figure 6




A) $1.70\times10^{3}$ N

B) $2.70\times10^{3}$ N

C) $3.70\times10^{3}$ N

D) $1.90\times10^{2}$ N

E) $6.70\times10^{4}$ N

**Ans:**

$$N = F \times \sin(\theta) + Mg \times \cos(\theta)$$

$$F \times \cos(\theta) = Mg \times \sin(\theta) \rightarrow F = Mg \times \tan(\theta)$$

$$N = Mg \times \tan(\theta) \times \sin(\theta) + Mg \times \cos(\theta) = \frac{Mg}{\cos(\theta)} = \frac{150 \times 9.8}{cos(30^{o})} = 1.7 \times 10^{3}\ N$$

---

**Q18.**

A 0.250 *kg* particle moves along an *x*-axis according to $x(t) = -26.00 + 4.00t + 8.00t^{2} - 6.00t^{3}$, where *x* is in meters and *t* is in seconds. In unit-vector notation, what is the net force acting on the particle at *t* = 2.50 s?

A) $(-18.5N)\hat{i}$

B) $(-17.5N)\hat{i}$

C) $(-19.5N)\hat{i}$

D) $(-28.5N)\hat{i}$

E) $(-38.5N)\hat{i}$

**Ans:**

$$x(t) = -26 + 4t + 8t^{2} - 6t^{3}$$

$$\frac{dx}{dt} = 4 + 16t - 18t^{2}$$

$$\frac{d^{2}x}{dt^{2}} = 16 - 32t$$

$$F = m\frac{d^{2}x}{dt^{2}} \rightarrow \vec{F} = m \times (16 - 32 \times 2.5)\hat{\imath} = -18.5N\ \hat{\imath}$$

---

**Q19.**

In three experiments, three horizontal forces are applied to the same block lying on the same table. The force magnitudes are $F_1 = 12\ N$, $F_2 = 8\ N$ , and $F_3 = 4\ N$. In each experiment, the block remains stationary in spite of the applied force. Rank the forces according to the maximum value $f_{s,\ max}$ of the static frictional force on the block from the table?

A) All three forces tie

B) $F_1$; $F_2$; $F_3$

C) $F_1$; $F_3$; $F_2$

D) $F_3$; $F_2$; $F_1$

E) $F_3$; $F_1$; $F_2$

**Ans:**

**A**

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**Q20.**

What is the smallest radius of an unbanked (flat) track around which a bicyclist can travel if his speed is 35 *km/h* and the $\mu_s$ between tires and track is 0.35?

A) 28 m

B) 25 m

C) 20 m

D) 35 m

E) 98 m

**Ans:**

$$m \times \frac{v^2}{R} \leq \mu_s \times mg \rightarrow R \geq \frac{v^2}{\mu_s \times g} = \frac{(35000/3600)^2}{0.35 \times 9.8} = 28\ m$$

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