Question 1: If $F_2 = 350$ N, $F_3 = 560$ N, and the resultant of these 3 forces is zero, determine the coordinate direction angle β_1 of force F_1.

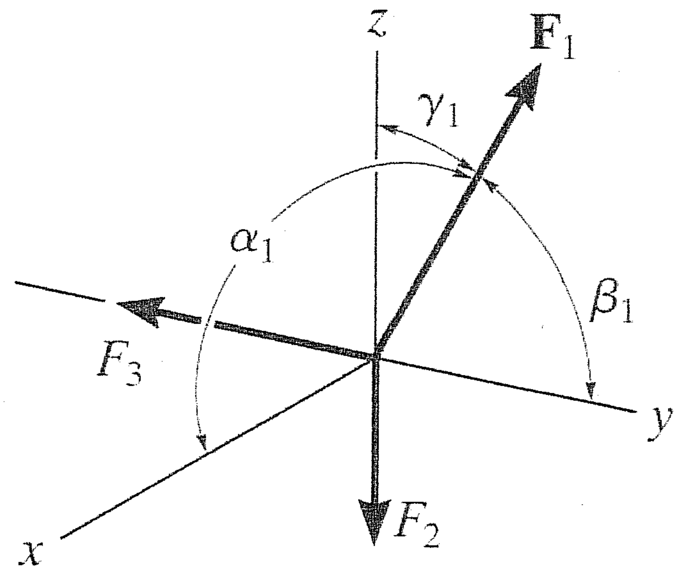
A) 58.0°

B) 40.3°

C) 45.0°

D) 32.0° ← Correct

E) 49.7°



For the resultant to be zero, we must have

$$\vec{F}_1 = 0\hat{i} + 560\hat{j} + 350\hat{k}$$

Since $F_{1y} = F_1 \cos\beta_1$

$$\beta_1 = \cos^{-1}\left[\frac{F_{1y}}{F_1}\right] = \cos^{-1}\left[\frac{560}{\sqrt{560^2 + 350^2}}\right]$$

$$= 32.0054°$$

Question 2: Determine the angle between F and the x-axis if $\theta_1 = 28°$ and $\theta_2 = 61°$.

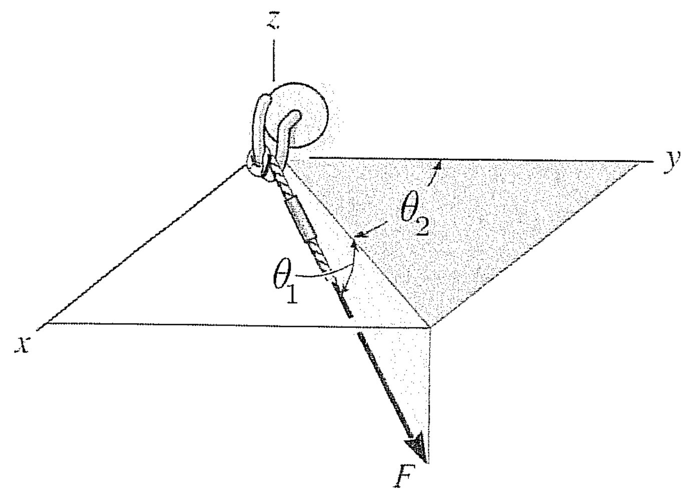
A) 76.8°

B) 39.4° ← Correct

C) The information provided is insufficient to determine the requested angle.

D) 29.0°

E) 64.7°



This is all about converting cartesian to direction-cosine angles.

$$F_x = F \cos\alpha = F \cos\theta_1 \sin\theta_2$$

$$\Rightarrow \cos\alpha = \cos\theta_1 \sin\theta_2$$

$$\Rightarrow \alpha = \cos^{-1}(\cos\theta_1 \sin\theta_2) = 39.4442°$$

Question 3: When vector $\vec{B}$ is added to vector $\vec{C} = 4\,\hat{\imath} - 3\,\hat{\jmath}$, the resultant vector is in the positive y direction and has a magnitude that is equal to the magnitude of $\vec{C}$. What is the magnitude of $\vec{B}$?

A) 4.47

B) 5.00

C) 80.0

D) 3.16

E) 8.94 ← Correct

Resultant vector $\vec{R} = \vec{B} + \vec{C}$

$$R_y = \sqrt{4^2 + (-3)^2} = 5$$

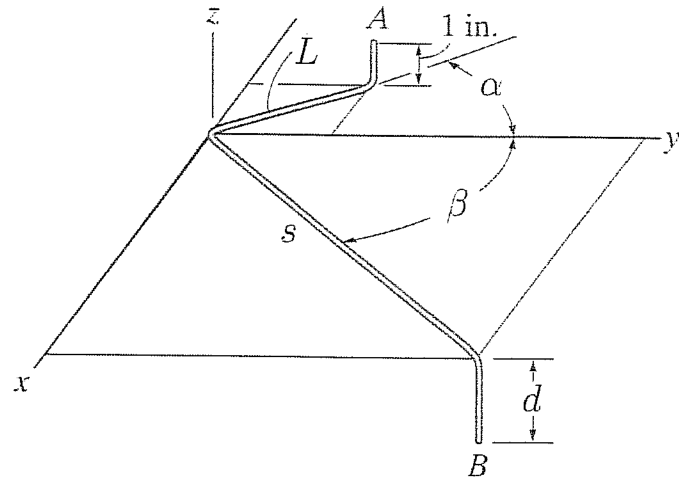
$$\Rightarrow \vec{R} = [B_x + 4]\,\hat{i} + [B_y + (-3)]\,\hat{j} = 0\,\hat{i} + 5\,\hat{j}$$

$$\Rightarrow B_x = -4$$

$$B_y = 5 + 3 = 8$$

$$\Rightarrow B = \sqrt{(-4)^2 + (8)^2} = 8.94427$$

Question 4: If $L = 3.3$ in, $s = 7.4$ in, $d = 2.5$ in, $\alpha = 24°$, and $\beta = 48°$, determine the distance between points A and B.



A) 7.93 in ← Correct

B) 11.1 in

C) 5.28 in

D) 14.2 in

E) 5.77 in

$$\vec{A} = -L\sin\alpha\,\hat{i} + L\cos\alpha\,\hat{j} + 1\,\hat{k}$$

$$\vec{B} = s\sin\beta\,\hat{i} + s\cos\beta\,\hat{j} - d\,\hat{k}$$

$$\Rightarrow \vec{B} - \vec{A} = (s\sin\beta + L\sin\alpha)\hat{i} + (s\cos\beta - L\cos\alpha)\hat{j} - (d+1)\hat{k}$$

$$= (7.4\sin 48° + 3.3\sin 24°)\hat{i} + (7.4\cos 48° - 3.3\cos 24°)\hat{j} - (2.5+1)\hat{k}$$

$$= 6.8415\,\hat{i} + 1.93687\,\hat{j} - 3.5\,\hat{k}$$

$$\Rightarrow |\vec{B} - \vec{A}| = \sqrt{6.8415^2 + 1.93687^2 + 3.5^2} = 7.92513 \text{ in}$$

Question 5: A rifle is aimed at the exact centre of a target located 77 m away. If the speed of the bullet as it exits the rifle is 240 m/s directed perfectly horizontally, at what distance from the centre of the target will the bullet hit this target (assume no wind and no friction)?

A) 157 cm

B) 0.00 cm → It will hit the target right in the centre.

C) 50.5 cm ⟵ Correct.

D) 29.3 cm

E) 47.7 cm

$x_f = 77\text{ m}$

In the x-dirn there is no acceleration

$\Rightarrow x_f = vt$

$\Rightarrow t = \frac{x_f}{v} = \frac{77}{240} = 0{\cdot}32083 \text{ s}$

$\Rightarrow y_f = -\frac{g}{2}t^2 = -\frac{9{\cdot}81}{2}(0{\cdot}32083)^2 = 50.4891 \text{ cm}$

Question 6: An airplane moves at a constant speed of 120 m/s as it travels around a vertical loop which has a radius of 1.5 km. What is the magnitude of the normal force exerted by the seat on the 99 kg pilot of this plane at the bottom of this loop?

A) 950 N

B) 1.92×10^3 N ← Correct

C) 20.8 N

D) 963 N

E) 979 N

At the bottom of the loop, normal force is in the upward dirn while gravity is in the downward dirn. Remember centripetal force is always towards the center of the circle.

$$\Rightarrow \quad ma = m\frac{v^2}{r} = N - mg$$

$$\Rightarrow \quad N = m\left[\frac{v^2}{r} + g\right]$$

$$= 99\left[\frac{120^2}{1.5\times10^3} + 9.81\right]$$

$$= 1921.59 \text{ N}$$

$$= 1.92 \times 10^3 \text{ N.}$$

Question 7: At time $t = 0$, a particle is located at $1\,\hat{\imath}$ m going at a speed of $-5\,\hat{\imath} + 3\,\hat{\jmath}$ m/s. If the particle maintains a constant acceleration of $8\,\hat{\jmath}$ m/s^2, what is its distance from the origin at $t = 3$ s?

A) 50.1 m

B) 25.2 m

C) 67.3 m

D) 31.0 m

E) 47.1 m $\leftarrow$ Correct.

Just use vector kinematic eqn.

$$\vec{r}_f = \vec{r}_i + \vec{v}t + \frac{1}{2}\vec{a}t^2$$

$$= 1\hat{i} + (-5\hat{i} + 3\hat{j})t + \frac{1}{2}8\hat{j}t^2$$

$$= (1 - 5t)\hat{i} + (3t + 4t^2)\hat{j}$$

$\because t = 3$ s.

$$\vec{r}_f = -14\hat{i} + 45\hat{j}$$

$$\Rightarrow d = |\vec{r}_f| = \sqrt{(-14)^2 + (45)^2} = 47.1275 \text{ m}$$

Question 8: A 19 kg mass is suspended by a string from the ceiling of an elevator that is moving upward with a speed which is decreasing at a constant rate of 4 m/s in each second. What is the tension in the string supporting the mass?

A) 186 N

B) 76.0 N

C) 262 N

D) 110 N $\leftarrow$ Correct.

E) 201 N

The elevator is moving upwards, but its speed is decreasing. $\Rightarrow$ The net acceleration is directed downwards.

$$\Rightarrow \quad ma = W - T$$

$$= mg - T$$

$$\Rightarrow \quad T = m(g-a) = 19\,(9.81 - 4)\ \mathrm{kg\,m/s^2}$$

$$= 110.39\ \mathrm{N}.$$

Question 9: Determine the weight of the ball I must hang at B so that my elephant at point A which weighs 14300 lb is in equilibrium as shown. Use $\theta = 31°$ and $\phi = 71°$.

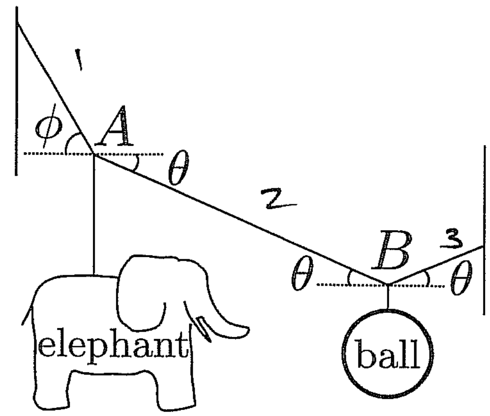
A) 4.90×10^3 lb

B) 7.46×10^3 lb ← Correct.

C) 2.10×10^4 lb

D) 3.73×10^3 lb

E) 3.61×10^4 lb



We solve this problem by writing the forces at A & B separately.

A in x : $0 = -T_1 \cos\phi + T_2 \cos\theta$.

A in y : $0 = T_1 \sin\phi - T_2 \sin\theta - m_E g$

B in x : $0 = -T_2 \cos\theta + T_3 \cos\theta$.

B in y : $0 = T_2 \sin\theta + T_3 \sin\theta - m_B g$

Soln.

From B in x : $T_2 = T_3$

From A in x : $T_1 = T_2 \dfrac{\cos\theta}{\cos\phi}$

From B in y : $m_B g = T_2 \sin\theta + T_3 \sin\theta = 2 T_2 \sin\theta$.

$$\Rightarrow T_2 = \frac{m_B g}{2 \sin\theta}.$$

From A in y ! $m_E g = T_1 \sin\phi - T_2 \sin\theta = T_2 \dfrac{\cos\theta}{\cos\phi} . \sin\phi - T_2 \sin\theta$

$\Rightarrow m_E g = T_2 (\cos\theta \tan\phi - \sin\theta) = \dfrac{m_B g}{2 \sin\theta} \cdot (\cos\theta \tan\phi - \sin\theta)$.

$\Rightarrow m_B g = \dfrac{2 m_E g \sin\theta}{(\cos\theta \tan\phi - \sin\theta)} = 7460.71$ lb

Question 10: Two blocks connected by a rope of negligible mass are dragged by a horizontal force $F = 56$ N. If $m_1 = 47$ kg, $m_2 = 13$ kg, and the coefficient of kinetic friction between each block and the surface is 0.365, what is the tension (T) in the rope?

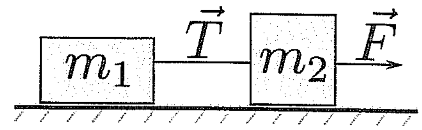
A) 9.45 N

B) 43.9 N

C) 56.0 N

D) 159 N

E) 258 N



There is an error in this question.

Normally this is how you solve this problem:

$$m_1 a = T - \mu_k m_1 g \Rightarrow a = \frac{T}{m_1} - \mu_k g.$$

$$m_2 a = F - \mu_k m_2 g - T \Rightarrow a = \frac{F}{m_2} - \mu_k g - \frac{T}{m_2}$$

$$\Rightarrow \frac{T}{m_1} - \cancel{\mu_k g} = \frac{F}{m_2} - \cancel{\mu_k g} - \frac{T}{m_2}$$

$$\Rightarrow T = \frac{m_1}{m_2} F - \frac{m_1}{m_2} T$$

$$\Rightarrow T\left(1 + \frac{m_1}{m_2}\right) = \frac{m_1}{m_2} F$$

$$\Rightarrow T = \frac{F}{\frac{m_2}{m_1} + 1} = \frac{56}{\frac{13}{47} + 1} = 43.8667 \text{ N} = 43.9 \text{ N}.$$

But there is a problem.

If you plug this T to calculate 'a', you get

$$a = \frac{43.9}{47} - 0.365(9.81) = -2.6466 \text{ m/s}^2$$

(contradiction).

Question 11: Which one quantity below has dimensions equal to $\left[\frac{\mathrm{M \cdot L}}{\mathrm{T^2}}\right]$? (Below, m is a mass, v a speed, r a radius, and F a force).

A) $\frac{mv^2}{r}$ $\leftarrow$ correct.

B) $\frac{1}{2}mv^2$

C) mv

D) rF

E) mrv

$$\frac{mv^2}{r} \sim \frac{M(LT^{-1})^2}{L} = MLT^{-2}$$

$$\frac{1}{2}mv^2 \sim M(LT^{-1})^2 = ML^2T^{-2}$$

$$mv \sim M(LT^{-1}) = MLT^{-1}$$

$$rF \sim L(MLT^{-2}) = ML^2T^{-2}$$

$$mrv \sim ML(LT^{-1}) = ML^2T^{-1}$$