Physical Problem Solving

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Question 1

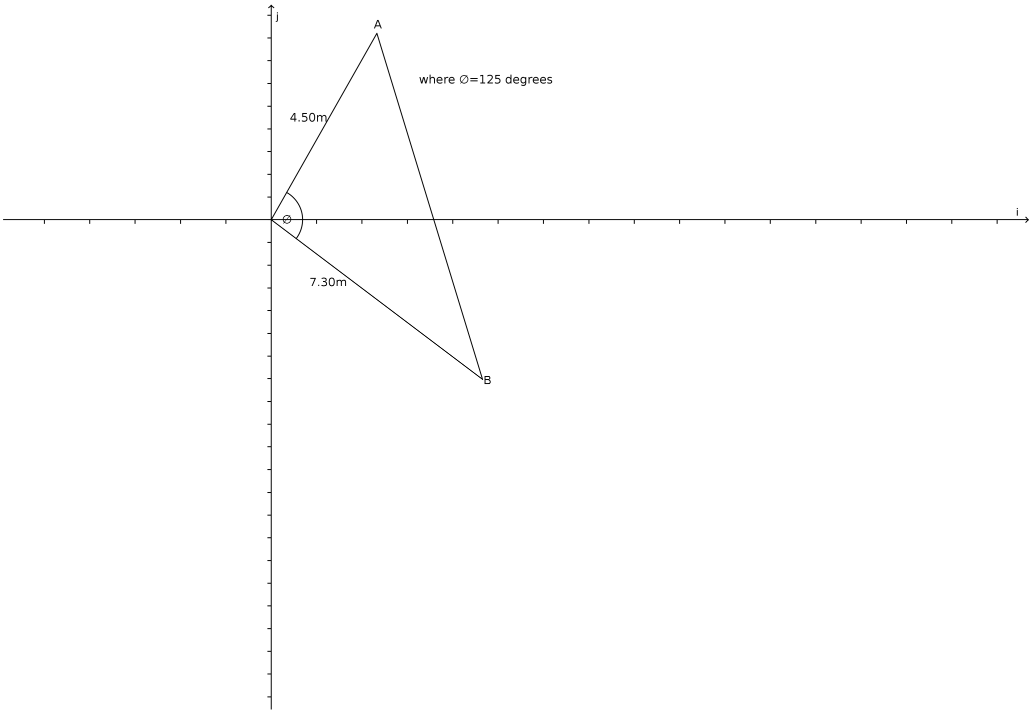

Figure 1: Vector Diagram

a $\overrightarrow{A}\,.\,\overrightarrow{B}$

The scalar product of the vectors is obtained by multiplying the magnitude of the vectors by the cosine of their angle.

$$\overrightarrow{A}\,.\,\overrightarrow{B} = |\overrightarrow{A}||\overrightarrow{B}|\cos\theta$$

$$\overrightarrow{A}\,.\,\overrightarrow{B} = 4.50 \times 7.30\cos(125°)$$
$$\therefore \overrightarrow{A}\,.\,\overrightarrow{B} = -18.84$$

b $\overrightarrow{A} \times \overrightarrow{B}$

Observe that the two vectors$\overrightarrow{A}$ and $\overrightarrow{B}$ have both i and j components, so we have to resolve these vectors both horzontally and vertically,we can write the vectors component-wise as;

$$\overrightarrow{A} = |\overrightarrow{A}|\cos(40°)\,\hat{\imath} - |\overrightarrow{A}|\sin(40°)\,\hat{\jmath}$$

$$\overrightarrow{B} = |\overrightarrow{B}|\cos(85°)\,\hat{\imath} + |\overrightarrow{B}|\sin(85°)\,\hat{\jmath}$$

We can now find the cross product of these two vectors by computing their determinant.

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ |\overrightarrow{A}|\cos(40^\circ) & -|\overrightarrow{A}|\sin(40^\circ) & 0 \\ |\overrightarrow{B}|\cos(85^\circ) & |\overrightarrow{B}|\sin(85^\circ) & 0 \end{vmatrix} \tag{1}$$

$$\therefore \overrightarrow{A} \times \overrightarrow{B} = \left(|\overrightarrow{A}||\overrightarrow{B}|\sin(85^\circ)\cos(40^\circ) + |\overrightarrow{A}||\overrightarrow{B}|\cos(85^\circ)\sin(40^\circ) \right) \hat{k}$$

$$\overrightarrow{A} \times \overrightarrow{B} = |\overrightarrow{A}||\overrightarrow{B}|\sin(85^\circ + 40^\circ)\,\hat{k}$$

$$\overrightarrow{A} \times \overrightarrow{B} = 4.50 \times 7.30\sin(125^\circ)\,\hat{k} = 26.90\hat{k}$$

We therefore conclude that the cross product of vector A and B produces a vector with magnitude 26.90 in the $\hat{k}$-direction.

Question 2

From the pieces of information given in the question,we have that; The horizontal distance between the boy and the middle of the basket is D,D can also be refered to as the range of the projectile motion, the angle of inclination is 55°,substituting these values into our range equation for the projectile motion,we shall obtain the initial velocity of the ball.

$$Range = \frac{U^2 \sin 2\theta}{g}$$

where $\theta = 55^\circ$, Range=4.20m and g=9.8ms^{-2}

$$U = \left(\frac{9.8 \times 4.2}{\sin(110^\circ)} \right)^{\frac{1}{2}}$$

$$U = 6.618ms^{-1}$$

Question 3

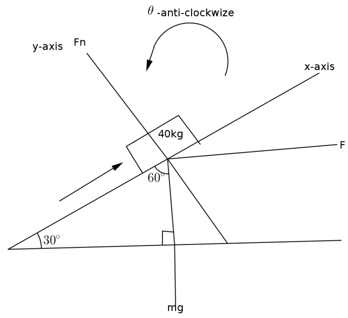

Figure 2: Force Diagram

Considering the force diagram of the box moving along an inclined plane as shown above, we can resolve the forces into their respective x and y components

Force	x-components	y-components
$\overrightarrow{Fn}$	Fncos90	Fnsin90
mg	mgcos(240)	mgsin(240)
$\overrightarrow{F}$	Fcos(330)	Fsin(330)

Now let's resolve the forces to their respective components,starting with the x-component R_x.

$$R_x = Fncos90 + mgcos240 + Fcos330 = ma$$

Since the body is moving at a constant speed, acceleration $a = 0$, so that the right hand part of the equation turns to zero.

$$R_x = Fncos90 + mgcos240 + Fcos330 = 0$$

Where m=40kg and g=9.8ms^{-2}

$$R_x = 0 - 196 + 0.866F = 0$$

$$F = \frac{-196}{-0.866} = 226.32N$$

Therefore the force required to sustain the motion is 226.32N.
Now let's consider the y-axis, we take as similar approach as we did for the x-axis.

$$R_y = Fnsin90 + mgsin240 + Fsin330 = ma.$$

$Acceleration = 0,\ F = 226.32N,\ ma = 0, sin90 = 1, m = 40kg, g = 9.8ms^{-1}.$

$$Fn - 339.481 - (226.32)(-0.5) = 0$$

$$\therefore Fn = 451.641N$$

The force exerted on the ramp by the crate is $451.641N$.