5.6 Applications of Dot and Cross Product Worksheet with solutions

This document was composed and formatted by Annie Bernatchez.

The course material originated from www.jensenmath.ca

1) Given $\vec{a} = [2,\ 4,\ -5]$, $\vec{b} = [-1,\ 3,\ 7]$, and $\vec{c} = [-2,\ 7,\ 3]$, evaluate each expression.

a) $\vec{a} \times \vec{b} \cdot \vec{c}$

$\vec{a} \times \vec{b} = [4(7) - (-5)(3),\ -5(-1) - 2(7),\ 2(3) - 4(-1)]$

$\vec{a} \times \vec{b} = [43,\ -9,\ 10]$

$\vec{a} \times \vec{b} \cdot \vec{c} = [43,\ -9,\ 10] \cdot [-2,\ 7,\ 3]$

$\vec{a} \times \vec{b} \cdot \vec{c} = -119$

b) $\vec{a} \times \vec{c} \cdot \vec{b}$

$\vec{a} \times \vec{c} = [4(3) - (-5)(7),\ -5(-2) - 2(3),\ 2(7) - 4(-2)]$

$\vec{a} \times \vec{c} = [47,\ 4,\ 22]$

$\vec{a} \times \vec{c} \cdot \vec{b} = [47,\ 4,\ 22] \cdot [-1,\ 3,\ 7]$

$\vec{a} \times \vec{c} \cdot \vec{b} = 119$

2) Determine the projection, and its magnitude of $\vec{u}$ on $\vec{v}$.

a) $\vec{u} = [2,\ 1,\ 7]$, $\vec{v} = [-7,\ 2,\ 6]$

$proj_{\vec{v}}\ \vec{u} = \frac{\vec{u} \cdot \vec{v}}{\vec{v} \cdot \vec{v}}(\vec{v})$

$proj_{\vec{v}}\ \vec{u} = \frac{2(-7) + 1(2) + 7(6)}{(-7)^2 + 2^2 + 6^2}[-7,\ 2,\ 6]$

$proj_{\vec{v}}\ \vec{u} = \frac{30}{89}[-7,\ 2,\ 6]$

$|proj_{\vec{v}}\ \vec{u}| = \frac{30}{89}\sqrt{89}$

$|proj_{\vec{v}}\ \vec{u}| = \frac{30}{\sqrt{89}}$

b) $\vec{u} = 7\vec{i} - 6\vec{j} + 5\vec{k}$, $\vec{v} = 3\vec{i} - 2\vec{j} + \vec{k}$

$proj_{\vec{v}}\ \vec{u} = \frac{7(3) + (-6)(-2) + 5(1)}{3^2 + (-2)^2 + 1^2}[3,\ -2,\ 1]$

$proj_{\vec{v}}\ \vec{u} = \frac{38}{14}[3,\ -2,\ 1]$

$|proj_{\vec{v}}\ \vec{u}| = \frac{38}{14}\sqrt{14}$

$|proj_{\vec{v}}\ \vec{u}| = \frac{38}{\sqrt{14}}$

3) Determine the work done in the direction of travel.

a) $\vec{F} = [200,\ 150,\ 75]$, $\vec{s} = [2,\ -1,\ 8]$

$W = \vec{F} \cdot \vec{s}$

$W = 200(2) + 150(-1) + 75(8)$

$W = 850\ J$

b) $\vec{F} = -3\vec{i} + 9\vec{j} + 5\vec{k}$, $\vec{s} = 2\vec{i} + 5\vec{j} + 3\vec{k}$

$W = \vec{F} \cdot \vec{s}$

$W = -3(2) + 9(5) + 5(3)$

$W = 54\ J$

4) Find the area of the parallelogram with sides consisting of the vectors.

a) $\vec{a} = [-4,\ 5,\ -8]$, $\vec{b} = [1,\ -2,\ 3]$

$\vec{a} \times \vec{b} = [5(3) - (-8)(-2),\ -8(1) - (-4)(3),\ -4(-2) - 5(1)]$

$\vec{a} \times \vec{b} = [-1,\ 4,\ 3]$

Area $= |\vec{a} \times \vec{b}| = \sqrt{26}$ units^2

b) $\vec{a} = [9,\ -5,\ 7]$, $\vec{b} = [3,\ -2,\ 5]$

$\vec{a} \times \vec{b} = [-5(5) - 7(-2),\ 7(3) - 9(5),\ 9(-2) - (-5)(3)]$

$\vec{a} \times \vec{b} = [-11,\ -24,\ -3]$

Area $= |\vec{a} \times \vec{b}| = \sqrt{706}$ units^2

5) Find the area of the triangle with the given vertices.

a) $A(0,\ 2,\ 4)$, $B(3,\ -2,\ 1)$, $C(4,\ -2,\ 5)$

$\overrightarrow{AB} = [3,\ -4,\ -3]$, $\overrightarrow{AC} = [4,\ -4,\ 1]$

$\overrightarrow{AB} \times \overrightarrow{AC} = [-4(1) - (-3)(-4),\ -3(4) - 3(1),\ 3(-4) - (-4)(4)]$

$\overrightarrow{AB} \times \overrightarrow{AC} = [-16,\ -15,\ 4]$

Area $= \frac{1}{2}|\overrightarrow{AB} \times \overrightarrow{AC}| = \frac{\sqrt{497}}{2}$ units^2

b) $A(-2,\ 4,\ 5)$, $B(1,\ 4,\ 2)$, $C(7,\ 4,\ 9)$

$\overrightarrow{AB} = [3,\ 0,\ -3]$, $\overrightarrow{AC} = [9,\ 0,\ 4]$

$\overrightarrow{AB} \times \overrightarrow{AC} = [0(4) - (-3)(0),\ -3(9) - 3(4),\ 3(0) - 0(9)]$

$\overrightarrow{AB} \times \overrightarrow{AC} = [0,\ -39,\ 0]$

Area $= \frac{1}{2}|\overrightarrow{AB} \times \overrightarrow{AC}| = \frac{39}{2}$ units^2

6) Determine the volume of the parallelepiped determined by the vectors.

a) $\vec{a} = [2,\ 5,\ -8]$, $\vec{b} = [7,\ -2,\ 3]$, and $\vec{c} = [8,\ 2,\ -1]$

$\vec{a} \times \vec{b} = [5(3) - (-8)(-2),\ -8(7) - 2(3),\ 2(-2) - 5(7)]$

$\vec{a} \times \vec{b} = [-1,\ -62,\ -39]$

$V = |\vec{a} \times \vec{b} \cdot \vec{c}| = |[-1,\ -62,\ -39] \cdot [8,\ 2,\ -1]|$

$V = 93$ units^3

b) $\vec{a} = [1,\ -5,\ 9]$, $\vec{b} = [3,\ 4,\ -7]$, and $\vec{c} = [1,\ 0,\ 2]$

$\vec{a} \times \vec{b} = [-5(-7) - 9(4),\ 9(3) - 1(-7),\ 1(4) - (-5)(3)]$

$\vec{a} \times \vec{b} = [-1,\ 34,\ 19]$

$V = |\vec{a} \times \vec{b} \cdot \vec{c}| = |[-1,\ 34,\ 19] \cdot [1,\ 0,\ 2]|$

$V = 37$ units^3

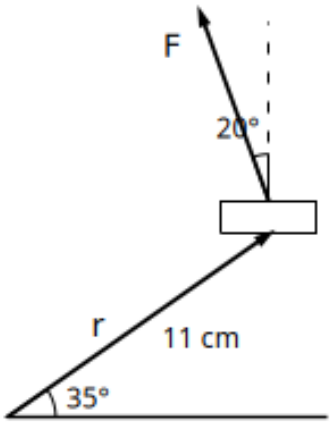
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7) Find the torque produced by a cyclist exerting a force of 85 N on the pedal in the position shown in the diagram, if the shaft of the pedal is 11 cm long.

$|\vec{\tau}| = |\vec{r}||\vec{F}|\sin\theta$

$|\vec{\tau}| = (0.11)(85)\sin 105$

$|\vec{\tau}| \cong 9.03\ N \cdot m$



8) A woman pushes her baby stroller a distance of 1500 m by a force of 89 N applied at an angle of 35° to the roadway. Calculate the work done.

$W = \vec{F} \cdot \vec{s}$

$W = 89(1500)\cos(35°)$

$W \cong 109\,356.8\ J$

9) Determine the work done by gravity in causing a 45 kg child to slide down a 55 m slope, which has an angle of 47° to the horizontal.

$|\vec{F}| = mg = (45)(9.8) = 441\ N$

$W = \vec{F} \cdot \vec{s}$

$W = 441(55)\cos(43°)$

$W \cong 17\,738.98\ J$

10) A force of 75 N is applied to a wrench in a clockwise direction at 52° to the handle, 17 cm from the centre of the bolt.

a) Calculate the magnitude of the torque.

$|\vec{\tau}| = |\vec{r}||\vec{F}|\sin\theta$

$|\vec{\tau}| = (0.17)(75)\sin 52$

$|\vec{\tau}| \cong 10.05\ N \cdot m$

b) In what direction does the bolt move?

The bolt is being tightened into the material.

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