5.3 Applications of the Dot Product Worksheet with solutions

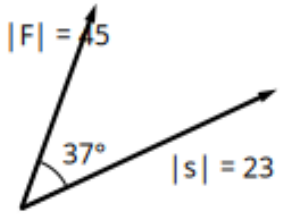
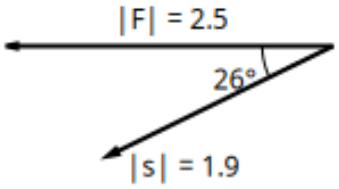
This document was composed and formatted by Annie Bernatchez.

The course material originated from www.jensenmath.ca

1) Determine the work done by each force $\vec{F}$, in Joules, for each object moving along $\vec{s}$.

a) $\vec{F} = [3, -2]$, $\vec{s} = [1, 8]$ $W = \vec{F} \cdot \vec{s}$ $W = 3(1) + (-2)(8)$ $W = -13$ Joules	b) $\vec{F} = [8, -9]$, $\vec{s} = [-3, 7]$ $W = 8(-3) + (-9)(7)$ $W = -87$ Joules

2) Determine the work done by the force $\vec{F}$, in Joules, for each object moving along $\vec{s}$.

a)  	b) 
$W = \vec{F} \cdot \vec{s}$ $W = \lvert\vec{F}\rVert\vec{s}\rvert\cos(37)$ $W = 45(23)\cos(37)$ $W \cong 826.59$ Joules	$W = \vec{F} \cdot \vec{s}$ $W = \lvert\vec{F}\rVert\vec{s}\rvert\cos(26)$ $W = 2.5(1.9)\cos(26)$ $W \cong 4.27$ Joules

3) Determine the angle between the vectors in each pair.

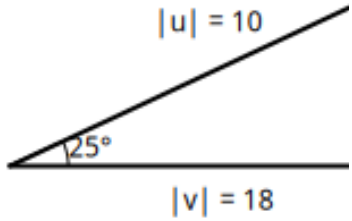
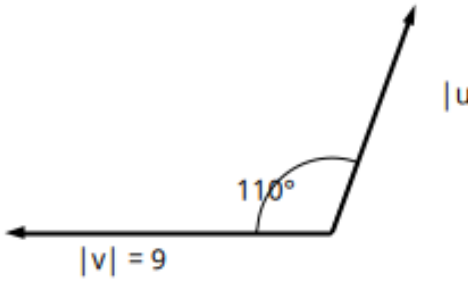
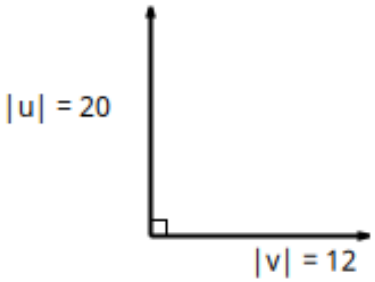
a) $\vec{p} = [6, 7]$ and $\vec{q} = [3, 2]$	b) $\vec{r} = [-1, -7]$ and $\vec{s} = [5, 4]$
$\cos\theta = \frac{\vec{p} \cdot \vec{q}}{\lvert\vec{p}\rVert\vec{q}\rvert}$ $\cos\theta = \frac{6(3) + 7(2)}{\left(\sqrt{(6)^2 + (7)^2}\right)\left(\sqrt{(3)^2 + (2)^2}\right)}$ $\cos\theta = \frac{32}{(\sqrt{85})(\sqrt{13})}$ $\theta \cong 15.71°$	$\cos\theta = \frac{\vec{r} \cdot \vec{s}}{\lvert\vec{r}\rVert\vec{s}\rvert}$ $\cos\theta = \frac{-1(5) + (-7)(4)}{\left(\sqrt{(-1)^2 + (-7)^2}\right)\left(\sqrt{(5)^2 + (4)^2}\right)}$ $\cos\theta = \frac{-33}{(\sqrt{50})(\sqrt{41})}$ $\theta \cong 136.79°$

4) Determine the projection of the first vector on the second.

a) $\vec{a} = [6, -1]$, $\vec{b} = [3, -4]$ $proj_{\vec{b}}\vec{a} = \frac{\vec{a} \cdot \vec{b}}{\vec{b} \cdot \vec{b}}(\vec{b})$ $= \frac{6(3) + (-1)(-4)}{3^2 + (-4)^2}[3, -4]$ $= \frac{22}{25}[3, -4]$ $= \left[\frac{66}{25}, \frac{-88}{25}\right]$	b) $\vec{c} = [6, 7]$, $\vec{d} = [3, 2]$ $proj_{\vec{d}}\vec{c} = \frac{\vec{c} \cdot \vec{d}}{\vec{d} \cdot \vec{d}}(\vec{d})$ $= \frac{6(3) + 7(2)}{3^2 + 2^2}[3, 2]$ $= \frac{32}{13}[3, 2]$ $= \left[\frac{96}{13}, \frac{64}{13}\right]$

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5) Determine the projection of $\vec{u}$ on $\vec{v}$

a)	b)	c)
		
$proj_{\vec{v}}\vec{u} = \lvert\vec{u}\rvert\cos\theta(\hat{v})$ $= 10\cos(25)\hat{v}$ $\cong 9.06\hat{v}$	$proj_{\vec{v}}\vec{u} = \lvert\vec{u}\rvert\cos\theta(\hat{v})$ $= 7\cos(110)\hat{v}$ $\cong -2.39\hat{v}$	$= \vec{0}$

6) For each of the following, find the magnitude of the projection of $\vec{x}$ on $\vec{y}$ and also the vector projection of $\vec{x}$ on $\vec{y}$.

a) $\vec{x} = [1, 1], \vec{y} = [1, -1]$

$$|proj_{\vec{y}}\vec{x}| = \left|\frac{\vec{x}\cdot\vec{y}}{|\vec{y}|}\right|$$

$$= \left|\frac{1(1)+1(-1)}{\sqrt{(1)^2+(-1)^2}}\right|$$

$$= 0$$

$$proj_{\vec{y}}\vec{x} = 0\left(\frac{\vec{y}}{|\vec{y}|}\right)$$

$$= \vec{0}$$

b) $\vec{x} = [2, 5], \vec{y} = [-5, 12]$

$$|proj_{\vec{y}}\vec{x}| = \left|\frac{\vec{x}\cdot\vec{y}}{|\vec{y}|}\right|$$

$$= \left|\frac{2(-5)+5(12)}{\sqrt{(-5)^2+(12)^2}}\right|$$

$$= \frac{50}{13}$$

$$proj_{\vec{y}}\vec{x} = \frac{50}{13}\left(\frac{[-5, 12]}{13}\right)$$

$$= \frac{50}{169}[-5, 12]$$

$$= \left[\frac{-250}{169}, \frac{600}{169}\right]$$

7) $\triangle DEF$ has vertices $D(-3, 5)$, $E(2, 3)$, and $F(6, 7)$. Calculate $\angle DEF$.

$\overrightarrow{ED} = [-5, 2]$

$\overrightarrow{EF} = [4, 4]$

$$\cos\theta = \frac{\overrightarrow{ED}\cdot\overrightarrow{EF}}{|\overrightarrow{ED}||\overrightarrow{EF}|}$$

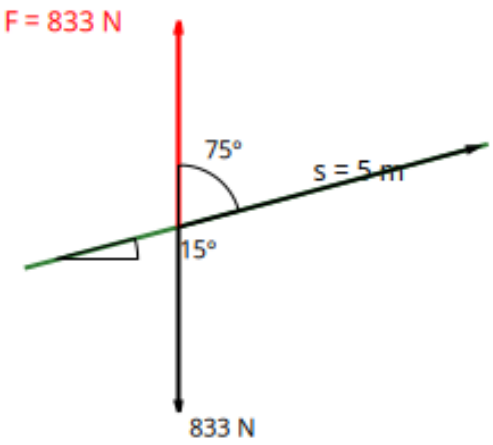
$$\cos\theta = \frac{-5(4)+2(4)}{(\sqrt{29})(\sqrt{32})}$$

$$\cos\theta = \frac{-12}{\sqrt{928}}$$

$\theta \cong 113.2°$

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8) How much work is done against gravity by the orderly pushing an 85 kg person up a 5 m ramp inclined at an angle of 15° to the horizontal?



$\vec{F} = 85(9.8) = 833$ N

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

$W = 833(5)\cos(75)$

$W \cong 1077.98$ J

9) A stage lamp is dragged 15 m along level ground by a 120 N force applied at an angle of 35° to the ground. It is then dragged up a 12 m ramp onto a stage by the same force. If the ramp is inclined at 15° to the ground. Find the total work done.

$W = 120(15)\cos(35°) + 120(12)\cos(20°)$

$W \cong 2827.63$ J

10) A box on a wagon pulled a distance of 35 m by a 27 N force applied at an angle of 40° to the ground. The box is then lifted a distance of 1.5 m and placed on a table by exerting a force of 37 N. Find the total work done.

$W = 27(35)\cos(40°) + 37(1.5)\cos(0)$

$W \cong 779.4$ J

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