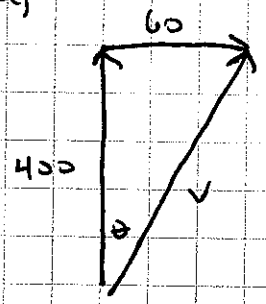
Relative Velocity

① a)



$v^2 = 60^2 + 400^2$ $\quad \theta = \tan^{-1}\left(\frac{60}{400}\right)$

$v = 404.475$ $\quad \theta = 8.531$

$v = 405$ km/h [8.5° E of N]

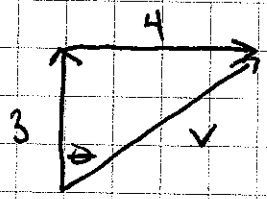
b) $d = vt$

$= (60)(2.5)$

$d = 150$ km

He would be 150 km [E] of due north.

② a)



$v^2 = 3^2 + 4^2$ $\quad \theta = \tan^{-1}\left(\frac{4}{3}\right)$

$v = 5$ $\quad \theta = 53.1$

$v = 5$ m/s [53° E of N]

b) $v = \frac{d}{t}$

$t = \frac{d}{v} = \frac{100\text{ m}}{3\text{ m/s}} = 33.\overline{3}\text{ s}$

c) $d = vt$

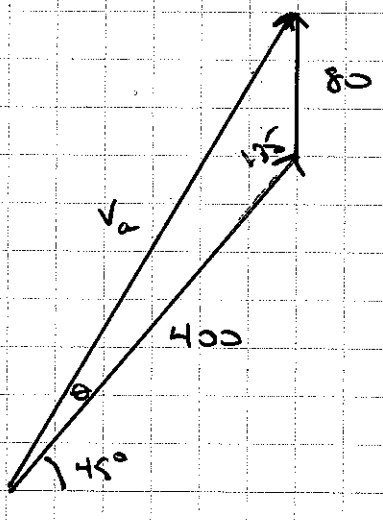
$= (4)(33.\overline{3})$

$d = 133.\overline{3}$ m

③ $V_g = \frac{300\ km}{0.75\ h} = 400\ km/h\ [NE]$

$\vec{V_g} = \vec{V_a} + \vec{V_w}$ $\qquad V_w = 80\ km/h\ [S]$

$\vec{V_a} = \vec{V_g} - \vec{V_w}$ $\qquad -V_w = 80\ km/h\ [N]$



$V_a^2 = 80^2 + 400^2 - 2(80)(400)\cos 135°$

$V_a = 460.060$

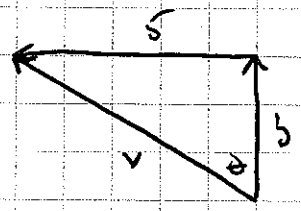
$\frac{\sin\theta}{80} = \frac{\sin 135°}{460.060}$

$\theta = \sin^{-1}\left(\frac{80\sin 135°}{460.060}\right)$

$\theta = 7.063 \quad (+45°)$

$V_a = 460\ km/h\ [52°\ N\ of\ E]$

④



$v^2 = 3^2 + 5^2$ $\qquad \theta = \tan^{-1}\left(\frac{5}{3}\right)$

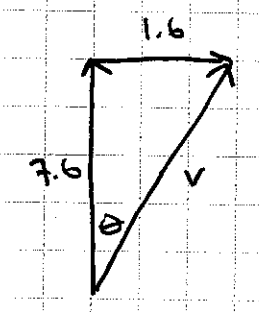
$v = 5.831$ $\qquad \theta = 59.036$

$v = 5.83\ m/s\ [59°\ W\ of\ N]$

⑤ a) $v = 1.6 + 7.6 = 9.2$ m/s [N]

b) $v = -1.6 + 7.6 = 6.0$ m/s [N]

c)

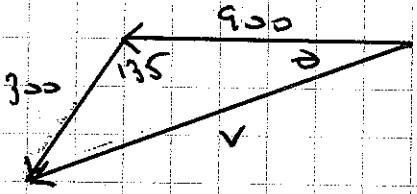


$v^2 = 1.6^2 + 7.6^2$ $\quad \theta = \tan^{-1}\left(\frac{1.6}{7.6}\right)$

$v = 7.767$ $\quad \theta = 11.889$

$v = 7.8$ m/s [12° E of N]

⑥



$v^2 = 300^2 + 900^2 - 2(300)(900)\cos 135$

$v = 1132.183$

$\frac{\sin\theta}{300} = \frac{\sin 135}{1132.183}$

$\theta = \sin^{-1}\left(\frac{300\sin 135}{1132.183}\right)$

$\theta = 10.799$

a) 11° S of W

b) 1132 Km/h

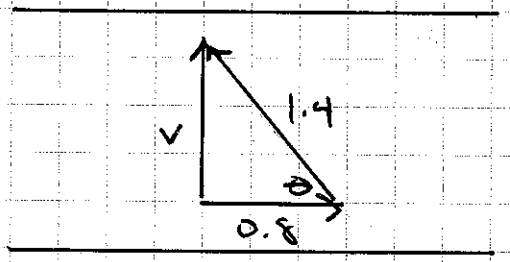
c) $t = \frac{d}{v} = \frac{500}{1132} = 0.44$ h

⑦ a) Shortest time is if she aims straight across.

$$t = \frac{d}{v} = \frac{70\text{ m}}{1.4\text{ m/s}} = 50\text{ s}$$

b) $d = vt = (0.80)(50) = 40\text{ m}$

c)



$$\cos\theta = \frac{0.8}{1.4}$$

$$\theta = \cos^{-1}\left(\frac{0.8}{1.4}\right)$$

$$\theta = 55.2°$$

d) $1.4^2 = v^2 + 0.8^2$

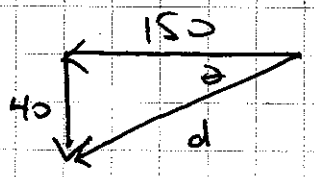
$v^2 = 1.4^2 - 0.8^2$

$v = 1.149$

$$t = \frac{d}{v} = \frac{70}{1.149}$$

$t = 60.927\text{ s}$

(8)



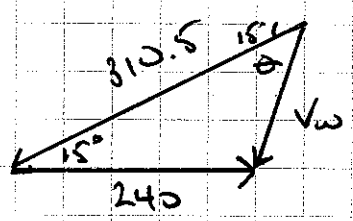
$d^2 = 40^2 + 150^2$ $\quad \theta = \tan^{-1}\left(\frac{40}{150}\right)$

$d = 155.242$ $\quad \theta = 14.931$

$$V_g = \frac{d}{t} = \frac{155.242}{0.5} = 310.484 \text{ Km/h } [15° \text{ S of W}]$$

a) $\vec{V_g} = \vec{V_c} + \vec{V_w}$

$\vec{V_w} = \vec{V_g} - \vec{V_c}$ $\quad -V_c = 240 \text{ Km/h } [E]$



$V_w^2 = 240^2 + 310.5^2 - 2(240)(310.5)\cos 15$

$V_w = 100.230$

$\frac{\sin\theta}{240} = \frac{\sin 15}{100.230}$

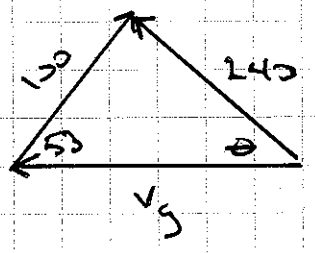
$\theta = \sin^{-1}\left(\frac{240 \sin 15}{100.230}\right)$

$\theta = 38.297 \quad (+15)$

$V_w = 100 \text{ Km/h } [53° \text{ S of W}]$

⑧ b) $\vec{V}_g = \vec{V}_a + \vec{V}_w$

$\vec{V}_a = \vec{V}_g - \vec{V}_w$ $\quad -V_w = 100 \text{ km/h } [53° \text{ N of E}]$



$$\frac{\sin\theta}{100.230} = \frac{\sin 53.297}{240}$$

$$\theta = \sin^{-1}\left(\frac{100.230 \sin 53.297}{240}\right)$$

$$\theta = 19.562$$

$\theta = 19.6°$ N of W

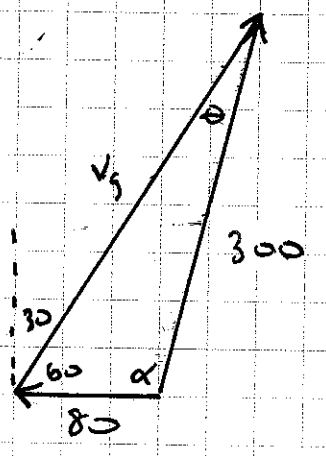
⑨ V_g = ___ Km/h [30° E of N]

V_a = 300 Km/h [??]

V_w = 80 Km/h [E]

a) $\vec{V_g} = \vec{V_a} + \vec{V_w}$

$\vec{V_a} = \vec{V_g} - \vec{V_w}$ $\quad -V_w = 80$ Km/h [W]



$\frac{\sin\theta}{80} = \frac{\sin 60}{300}$

$\theta = \sin^{-1}\left(\frac{80\sin 60}{300}\right)$

$\theta = 13.352$

$\alpha = 180 - 60 - 13.352 = 106.648$

heading = $106.648 - 90 = 16.648°$ E of N

b) $V_g^2 = 80^2 + 300^2 - 2(80)(300)\cos 106.648$

$V_g = 331.89$ Km/h

$t = \frac{d}{V_g} = \frac{1200}{331.89} = 3.62$ h

c) $t = \frac{d}{V_a} = \frac{1200}{300} = 4$ h

It saved 0.38 h