All:

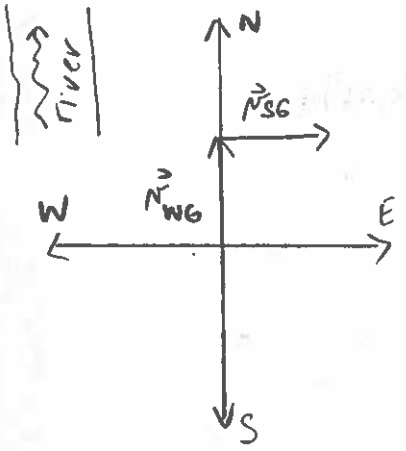
P12

KEY

/36

Relative Velocity – Practice

1. **A swimmer has a velocity of 2.0 m/s directly across a river that is flowing at 4.0 m/s. What is the actual velocity of the simmer? Draw vectors and clearly identify angle theta.**



$\vec{v}_{WG} = [0, 4.0]$ m/s

$\vec{v}_{SG} = [2.0, 0]$ m/s

$\vec{v}_{SW} = \vec{v}_{SG} + \vec{v}_{GW}$

$= [2.0, 0] + [0, -4.0]$

$= [2.0, -4.0]$ m/s

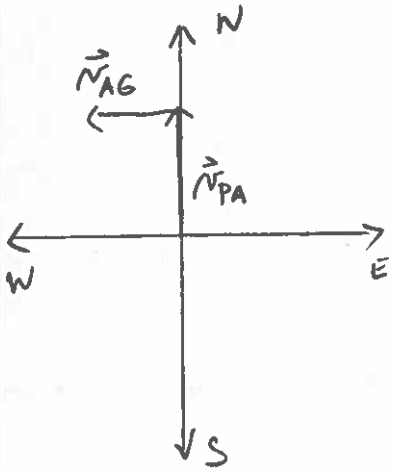
$\|\vec{v}_{SW}\| = \sqrt{(2.0)^2 + (-4.0)^2}$

$= 4.5$ m/s

$\theta = \tan^{-1}\left(\frac{4}{2}\right) = 63°$

∴ Swimmer's actual velocity is $4.5^{m}/_{s}[E63°S]$

2. **A plane is flying at 100 m/s due north with a cross wind (perpendicular to plane's velocity) of 20 m/s to the west. What is the plane's actual velocity and angel from true north?**



$\vec{v}_{PA} = [0, 100]$ m/s

$\vec{v}_{AG} = [-20, 0]$ m/s

$\vec{v}_{PG} = \vec{v}_{PA} + \vec{v}_{AG}$

$= [0, 100] + [-20, 0]$

$= [-20, 100]$ m/s

$\|\vec{v}_{PG}\| = \sqrt{(-20)^2 + 100^2}$

$= \sqrt{10400}$

$= 101.9804$ m/s

$\theta = \tan^{-1}\left(\frac{100}{20}\right)$

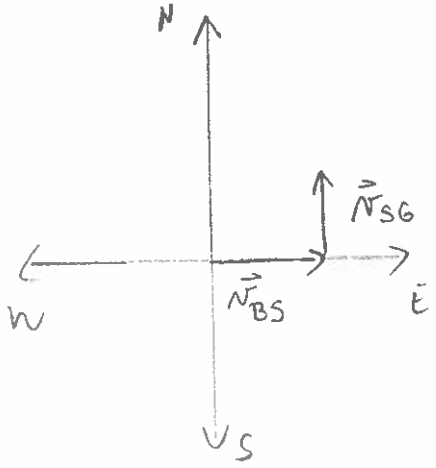
$\theta = 79°$

$[W\ 79°N]$

∴ Plane's actual velocity is 1.0×10^{2} m/s 11° W of N.

G = ground
S = stream
B = boat

3. **A sailboat is on a heading of due East at 5.0 m/s while crossing the Gulf Stream current, which is moving 4.0m/s due North. What is the sailboat's actual speed and heading?**



$\vec{v}_{BS} = [5.0, 0]$ m/s

$\vec{v}_{SG} = [0, 4.0]$ m/s

$\vec{v}_{BG} = \vec{v}_{BS} + \vec{v}_{SG}$

$= [5.0, 0] + [0, 4.0]$

$= [5.0, 4.0]$

$\|\vec{v}_{BS}\| = \sqrt{41}$

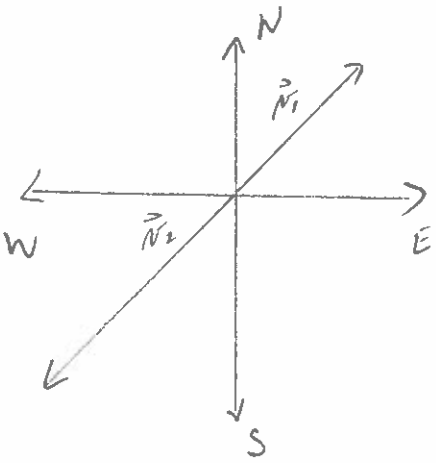
$= 6.4$ m/s

$\theta = \tan^{-1}\left(\frac{4}{5}\right)$

$\theta = 39°$

∴ Sailboat's actual speed is 6.4 m/s and its heading is S 39° N

4. **A plane leaves Atlanta flying northeast at 100 m/s. Another plane leaves Atlanta flying southwest at 150 m/s. What is their velocity relative to each other?**



$\vec{v}_{1A} = [100\cos 45°, 100\sin 45°]$

$= [70.7107, 70.7107]$ m/s

$\vec{v}_{2A} = [-150\cos 45°, -150\sin 45°]$

$= [-106.0660, -106.0660]$ m/s

$\vec{v}_{12} = \vec{v}_{1A} + \vec{v}_{A2}$ And $\vec{v}_{21} = \vec{v}_{2A} + \vec{v}_{A1}$

$= [70.7107, 70.7107] + [106.0660, 106.0660]$

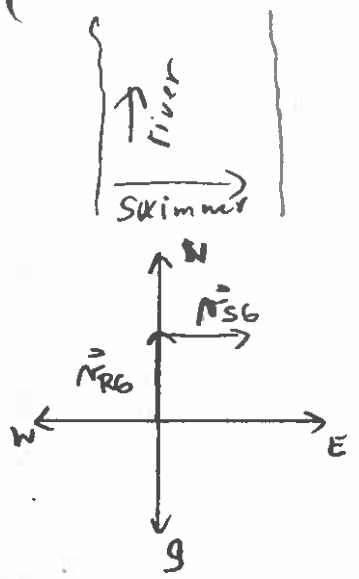
$= [176.7767, 176.7767]$ m/s

$\|\vec{v}_{12}\| = 250$ m/s $\Rightarrow \|\vec{v}_{21}\| = 250$ m/s

∴ $\vec{v}_{12} = 250$ m/s [NE].

∴ $\vec{v}_{21} = 250$ m/s [SW].

5. **A swimmer's path appears to be going directly across a river at 1.5 m/s. The current is 2.0 m/s. How fast and at what direction must she be swimming?**



$\vec{v}_{RG} = [0, 2.0]$ m/s

$\vec{v}_{SG} = [1.5, 0]$ m/s

$\vec{v}_{SR} = \vec{v}_{SG} + \vec{v}_{GR}$

$= [1.5, 0] + [0, -2.0]$

$= [1.5, -2.0]$ m/s

$\|\vec{v}_{SR}\| = \sqrt{1.5^2 + (-2.0)^2}$

$= \sqrt{6.25}$

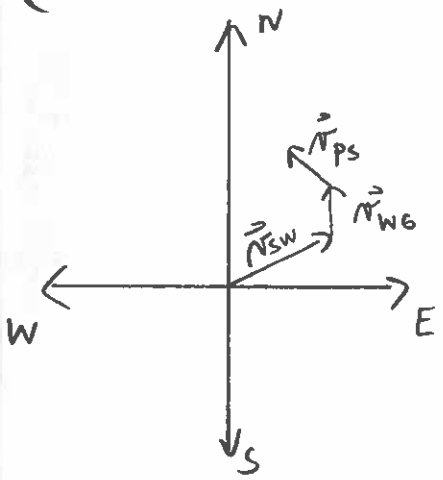
$= 2.5$ m/s

$\theta = \tan^{-1}\left(\frac{2}{1.5}\right)$

$\theta = 53°$

∴ The swimmer is swimming at 2.5 m/s [E 53°S] [across 53° against the stream].

6. **A ship is heading 30° N of E at 10 m/s. The ocean currents are flowing north at 1.0 m/s. A man walked across the ship 1.0m/s in a direction perpendicular to the ship (30° W of N). Draw all the vectors. Add vectors algebraically to determine the velocity of the man relative to the earth.**



$\vec{v}_{SW} = [10 \cdot \cos 30°, 10 \cdot \sin 30°]$

$= [8.6603, 5.0]$ m/s

Current $\vec{v}_{WG} = [0, 1.0]$ m/s

$\vec{v}_{PS} = 1.0\ [W\ 60°\ N]$!

$= [-\cos 60°, \sin 60°]$

$= [-0.5, 0.8660]$ m/s

$\vec{v}_{PG} = \vec{v}_{PS} + \vec{v}_{SW} + \vec{v}_{WG}$

$= [-0.5, 0.8660] + [8.6603, 5.0] + [0, 1.0]$

$= [8.1603, 6.8660]$ m/s

$\|\vec{v}_{PG}\| = \sqrt{113.7324}$

$= 11$ m/s

$\theta = \tan^{-1}\left(\frac{6.866}{8.1603}\right)$

$\theta = 40°$

∴ The person's velocity relative to Earth is 11 m/s [E 40° N]