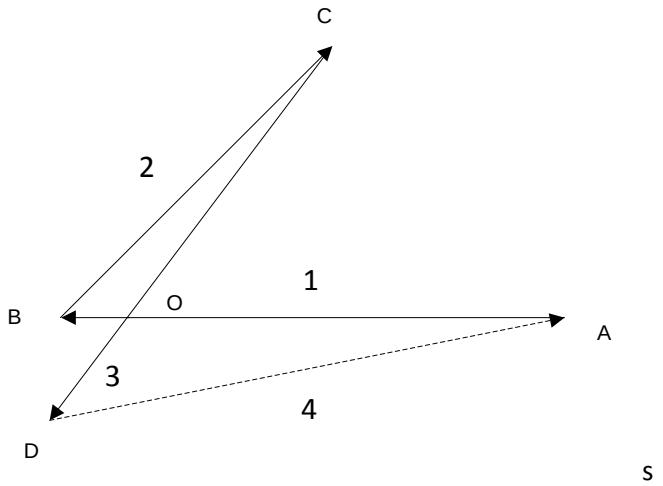
We have next picture:



And we have:

$AB = 670$

$BC = 510$

$CD = 620$

$\angle ABC = 45°$

$\angle BCD = 8°$

$AC = \sqrt{670^2 + 510^2 - 2 \cdot 670 \cdot 510 \cdot \cos 45°} \approx 475.15$

$\angle BOC = 127°$

$$\frac{670}{\sin \angle ACB} = \frac{475.15}{\sin \angle ABC} = \frac{475.15}{\sin 45°} \Rightarrow \sin \angle ACB = \frac{670 \cdot \sin 45°}{475.15} \Rightarrow$$

$$\Rightarrow \angle ACB = \arcsin\left(\frac{670 \cdot \sin 45°}{475.15}\right) = 85.6°$$

$\angle ACD = \angle ACB - 8° = 85.6° - 8° = 77.6°$

$AD = \sqrt{620^2 + 475.15^2 - 2 \cdot 620 \cdot 475.15 \cdot \cos 77.6°} = 695.6;$

$$\frac{695.6}{\sin 77.6°} = \frac{475.15}{\sin \angle ADC} \Rightarrow$$

$$\Rightarrow \angle ADC = \arcsin\left(\frac{475.15 \cdot \sin 77.6°}{695.6}\right) = 41.8°$$

$\angle BAD = 180° - 127° - 41.8° = 11.2°$

So, we can say that total displacement of the plane is: magnitude = 695.6 km and direction = 11.2 degree south of west.

And the magnitude and the direction of a fourth trip are: magnitude = 695.6 km and direction = 11.2 degree north of east.

Answer: **a.** magnitude = 695.6 km and direction = 11.2 degree south of west.

b. magnitude = 695.6 km and direction = 11.2 degree north of east.