Assignment 2.02 - Relative Motion KEY

1. George is riding his bicycle to the east at 10 m/s. There is a car, 100 meters away, coming toward him at 30 m/s. How long does George have to react in order to avoid a collision?

$$v_{relative} = v_{bicycle} + v_{car} = 10m/s + 30m/s = 40m/s$$

$$v = \frac{d}{t} \Longrightarrow t = \frac{d}{v} = \frac{100m}{40m/s} = 2.5s$$

2. Monique leaves her house and walks to school at a rate of 1.5 m/s. At the same time, Rick leaves the school and walks toward Monique's house at a speed of 2 m/s. Monique's house is 1200 meters from the school.

   (a) How long does it take for Monique and Rick to meet?

$$v_{relative} = v_{Monique} + v_{Rick} = 1.5m/s + 2m/s = 3.5m/s$$

$$v = \frac{d}{t} \Longrightarrow t = \frac{d}{v} = \frac{1200m}{3.5m/s} \approx 342.857s \approx 5 \text{ min } 42.857\text{s}$$

   (b) How far from Monique's house do they meet?

$$v = \frac{d}{t} \Longrightarrow d = v \times t = 1.5m/s * 342.857s \approx 514.286m$$

3. Ernest, a police officer, is in pursuit of a car that has been stolen by the notorius criminal Bert. Bert is 5 km ahead of the police car. Bert drives 30 m/s, and the Ernest is catching up by driving 45 m/s. *Note: 5 km = 5000 m

   (a) How long does it take for Ernest to catch up?

$$v_{relative} = v_{Ernest} - v_{Bert} = 45m/s - 30m/s = 15m/s$$

$$v = \frac{d}{t} \Longrightarrow d = \frac{d}{v} = \frac{5000m}{15m/s} \approx 333.333s \approx 5 \text{ min } 33.333\text{s}$$

   (b) How far does the Bert drive during that time?

$$v = \frac{d}{t} \Longrightarrow d = v \times t = 45m/s * 333.333s \approx 15000m = 15km$$

   (c) A car, coming from the other direction, driven by an innocent bystander named Zoey, is traveling 20 m/s. How fast does she see the thief go by?

$$v_{relative} = v_{Zoey} + v_{Bert} = 20m/s + 30m/s = 50m/s$$

4. Billy-Bob is flying 100 m/s in a plane directly above a road. He sees a car driving in the same direction, 550 meters in front of him. It takes the plane 7.25 seconds to pass the car. How fast is the car driving? *Note: There are multiple correct ways to solve this problem.

$$v_{relative} = \frac{d}{t} = \frac{550m}{7.25s} \approx 75.826m/s$$
$$v_{relative} = v_{plane} - v_{car} \Longrightarrow v_{car} = v_{plane} - v_{relative} = 100m/s - 75.862m/s \approx 24.138m/s$$

5. Louis is in a fighter plane, chasing an imperial Zero fighter near Hawaii. He is flying 60 m/s, and his guns have a forward velocity of 300 m/s. He fires a single shot at the fighter, which is 450 m away. The Zero fighter is fleeing at a speed of 95 m/s.

   (a) What is the speed of his bullet, as measured by an observer on the ground?

   $$v_{relative-to-ground} = v_{Louis} + v_{bullet} = 60m/s + 300m/s = 360m/s$$

   (b) What speed does the pilot of the Zero fighter see the bullet coming toward him at?

   $$v_{relative-to-zero} = v_{relative-to-ground} - v_{zero} = 360m/s - 95m/s = 265m/s$$

   (c) How long does it take for the bullet to hit the imperial fighter?

   $$v_{relative-to-zero} = \frac{d}{t} \Longrightarrow t = \frac{d}{v_{relative-to-zero}} = \frac{550m}{265m/s} \approx 2.075s$$

   (d) What is the total distance that the bullet travels?

   $$v_{relative-to-ground} = \frac{d}{t} \Longrightarrow d = v_{relative-to-ground} \times t = 360m/s * 2.075s \approx 747.170m$$

   (e) What is the date that these events took place?

   December 7, 1941

6. Salma is swimming 40m west of the shore when she sees a shark 78m west of her. She attempts to swim to the shore at a speed of 4 m/s. The shark pursues her at a speed of 12 m/s. Does Salma make it to the shore safely?

Salma:

$$v = \frac{d}{t} \Longrightarrow t = \frac{d}{v} = \frac{40m}{4m/s} = 10s$$

Shark:

$$v = \frac{d}{t} \Longrightarrow t = \frac{d}{v} = \frac{118m}{12m/s} \approx 9.833s$$