1 Kinematics

1. A motorboat going going downstream overcame a raft at point A; $\tau = 60$ min later it turned back and after some time passed the raft at a distance $l = 6.0$ km from the point A. Find flow velocity assuming the duty of the engine to be constant.

Solution:
Let u be the flow velocity and v be velocity of boat in still water,

$$\frac{l}{u} = \tau + \frac{(u+v)\tau - l}{v-u} \tag{1.1}$$

$$u = \frac{l}{2\tau} = \frac{6}{2 \cdot 1} = 3 \text{ km/hr} \tag{1.2}$$

2. A point traversed half the distance with a velocity v_0. The remaining part of the distance was covered with velocity v_1 for half the time, and with velocity v_2 for the other half of the time. Find the mean velocity of the point averaged over the whole time of motion.

Solution:

$$v_{av} = \frac{2 \cdot v_0 \cdot \frac{v_1+v_2}{2}}{v_0 + \frac{v_1+v_2}{2}} \tag{2.1}$$

3. A car starts moving rectilinearly, first with acceleration $w = 5.0\ ms^{-2}$ (the initial velocity is equal to zero), then uniformly, and finally, decelerating at the same rate w, comes to a stop. The total time of motion equals $\tau = 25$ s. The average velocity during that time is equal to $< v >= 72$ kmph. How long does the car move uniformly?

Solution:
Let the time for which car moves with acceleration be t since they are equal and let total time be T,

$$S = \frac{1}{2}wt^2 + wt \cdot (T - 2t) + wt^2 - \frac{1}{2}wt^2 \tag{3.1}$$

$$S = wtT - wt^2 \tag{3.2}$$

Let the average velocity be v,

$$v = \frac{wtT - wt^2}{T} \tag{3.3}$$

$$t^2 \cdot w - t \cdot wT + vT = 0 \tag{3.4}$$

$$t = \frac{wT + \sqrt{wT^2 - 4vwT}}{2w} \tag{3.5}$$

$$t = 5, 20 \text{ sec} \tag{3.6}$$

$t = 20$ sec will be rejected as $2t > T$ so time for which the object moves uniformly $= T - 2t = 25 - 2 \cdot 5 = 15$ sec.

4. Two particles, 1 and 2, move with constant velocities $\vec{v_1}$ and $\vec{v_2}$. At the initial moment, their radius vectors are equal to $\vec{r_1}$ and $\vec{r_2}$. How must these four vectors be interrelated for the particles to collide?

Solution:
For these particles to collide,

$$\vec{s_1} = \vec{s_2} \tag{4.1}$$

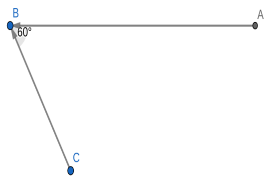
$$\vec{r_1} + \vec{v_1} \cdot t = \vec{r_2} + \vec{v_2} \cdot t \tag{4.2}$$

$$\vec{r_1} - \vec{r_2} = t(\vec{v_2} - \vec{v_1}) \tag{4.3}$$

$$\frac{\vec{r_1} - \vec{r_2}}{|\vec{r_1} - \vec{r_2}|} = \frac{\vec{v_2} - \vec{v_1}}{|\vec{v_2} - \vec{v_1}|} \tag{4.4}$$

5. A ship moves along the equator to the east with velocity $v_0 = 30$ km/hour. The southeastern wind blows at an angle $\phi = 60°$ to the equator with velocity $v = 15$ km/hour. Find the wind velocity v' relative to the ship and the angle ϕ' between the equator and the wind direction in the reference frame fixed to the ship.

Solution:



(5.1)

6. If there are n ants on each vertex of n sided regular polygon with side length a. If the first moves towards the second, second moves towards third, and so on then if they move with speed v, how long will it take them to converge at a single point?

Solution:

$$T = \frac{a}{v + v \cdot cos(\frac{\pi(n-2)}{n})} \tag{6.1}$$

$$T = \frac{a}{v - v \cdot cos(\frac{2\pi}{n})} \tag{6.2}$$

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Solution: