

# Gate2022.IN.39

EE22BTECH11008 - Annapureddy Siva Meenakshi\*

Q: A car is moving collinearly with a laser beam emitted by a transceiver. A laser pulse emitted at  $t = 0$  s is received back by the transceiver 100 ns (nanoseconds) later after reflection from the car. A second pulse emitted at  $t = 0.1$  s is received back 90 ns later. Given the speed of light is  $3 \times 10^8$  m/s, the average speed of the car in this interval is \_\_\_\_.

- (A) 54 kmph, moving towards the transceiver  
 (B) 108 kmph, moving towards the transceiver  
 (C) 54 kmph, moving away from the transceiver  
 (D) 108 kmph, moving away from the transceiver

**Solution:**

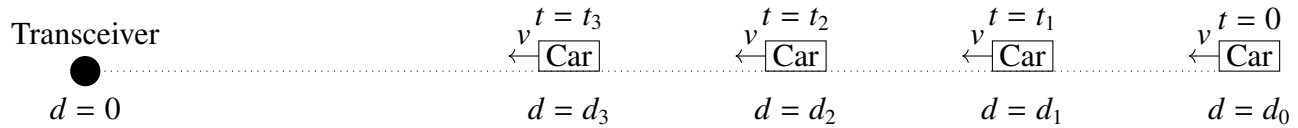


Fig. 0: block diagram of the system

Variable	Description	Value
$v_c$	velocity of laser	$3 \times 10^8$ m/s
$v$	average speed of car	none
$t_1$	time at which first pulse hits car	none
$t_2$	time at which second pulse is emitted	0.1s
$t_3$	time at which second pulse hits car	none
$d_0$	Distance between transceiver and car at $t = 0$	none
$d_1$	Distance between transceiver and car at $t = t_1$	none
$d_2$	Distance between transceiver and car at $t = t_2$	none
$d_3$	Distance between transceiver and car at $t = t_3$	none

TABLE 0: Input parameters

From Fig. 0

$$t_1 = \frac{d_1}{v_c} = \frac{d_0 - d_1}{v} \quad (1)$$

$$\Rightarrow d_1 = \frac{d_0}{\left(1 + \frac{v}{v_c}\right)} \quad (2)$$

Distance travelled by first pulse is given by

$$2d_1 = v_c \times 100 \text{ ns} \quad (3)$$

$$2 \frac{d_0}{\left(1 + \frac{v}{v_c}\right)} = v_c \times 100 \text{ ns} \quad (4)$$

similarly time taken by car to move from  $d_2$  to  $d_3$  is given by

$$t_3 - t_2 = \frac{d_3}{v_c} = \frac{d_2 - d_3}{v} \quad (5)$$

$$\Rightarrow d_3 = \frac{d_2}{\left(1 + \frac{v}{v_c}\right)} \quad (6)$$

from Fig. 0

$$d_2 = d_0 - 0.1v \quad (7)$$

$$\therefore d_3 = \frac{d_0 - 0.1v}{\left(1 + \frac{v}{v_c}\right)} \quad (8)$$

Distance travelled by second pulse is given by

$$2d_3 = v_c \times 90 \text{ ns} \quad (9)$$

$$2 \frac{d_0 - 0.1v}{\left(1 + \frac{v}{v_c}\right)} = v_c \times 90 \text{ ns} \quad (10)$$

solving (4) and (10) we get

$$v = 15 \text{ m/s} \quad (11)$$

$$v = 54 \text{ Km hr} \quad (12)$$