2000 – LINEAR MOTION QUESTION

1. **(a)** A stone projected vertically upwards with an initial speed of u m/s rises 70 m in the first t seconds and another 50 m in the next t seconds.

   Find the value of u.

   (b) A car, starting from rest and travelling from p to q on a straight level road, where $|pq| = 10\,000$ m, reaches its maximum speed 25 m/s by constant acceleration in the first 500 m and continues at this maximum speed for the rest of the journey.

   A second car, starting from rest and travelling from q to p, reaches the same maximum speed by constant acceleration in the first 250 m and continues at this maximum speed for the rest of the journey.

   (i) If the two cars start at the same time, after how many seconds do the two cars meet ?
   Find, also, the distance travelled by each car in that time.

   (ii) If the start of one car is delayed so that they meet each other exactly halfway between p and q, find which car is delayed and by how many seconds.

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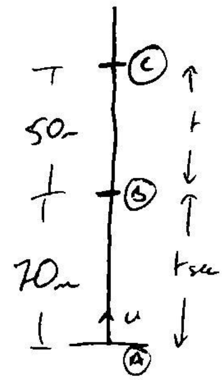
Q1

(a)



$A \to B$

$u = u$

$v = -$

$a = -g$

$S = 70$

$T = T$

$S = uT + \frac{1}{2}aT^2$

$70 = uT + \frac{1}{2}(-g)(T)^2$

$$\boxed{70 = uT - \frac{g}{2}T^2}$$

$A \to C$

$u = u$

$v = -$

$a = -g$

$S = 120$

$T = 2T$

$S = uT + \frac{1}{2}aT^2$

$120 = u(2T) + \frac{1}{2}(-g)(2T)^2$

$120 = 2uT - \frac{g}{2}(4T^2)$

$120 = 2uT - 2gT^2$

$60 = uT - gT^2$

$$\therefore \boxed{60 + gT^2 = uT}$$

so

$70 = 60 + gT^2 - \frac{g}{2}T^2 \quad \times 2$

$140 = 120 + 2gT^2 - gT^2$

$20 = gT^2$

$$\boxed{\sqrt{\frac{20}{g}} = T}$$

$$60 + gT^2 = uT$$

$$60 + g\left(\sqrt{\frac{20}{g}}\right)^2 = u\left(\sqrt{\frac{20}{g}}\right)$$

$$60 + \frac{20g}{g} = u\sqrt{\frac{20}{g}}$$

$$80 = u\sqrt{\frac{20}{g}}$$

$$6400 = u^2\left(\frac{20}{g}\right)$$

$$320g = u^2$$

$$\sqrt{320g} = u$$

$$56\,m/s = u.$$

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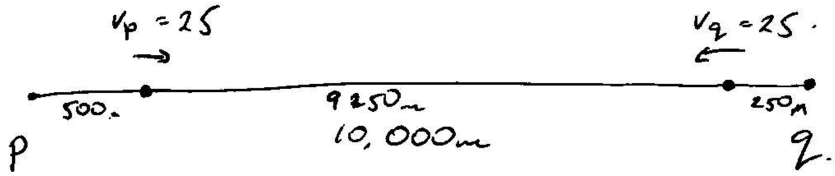
Q.1 (b)

(i)



(P)

$u = 0$
$v = 25$
$a = ?$
$s = 500$
$T = ?$

$v^2 = u^2 + 2as$

$(25)^2 = (0)^2 + 2(a)(500)$

$625 = 1000a$

$0.625\ ms^{-2} = a_p$

$v = u + aT$

$25 = 0 + (0.625)(T)$

$25 = 0.625T$

$40\,sec = T_p$

(q)

$u = 0$
$v = 25$
$a = ?$
$s = 250$
$T = ?$

$v^2 = u^2 + 2as$

$(25)^2 = (0)^2 + 2a(250)$

$625 = 500a$

$1.25\ ms^{-2} = a_q$.

$v = u + aT$

$25 = 0 + 1.25(T)$

$25 = 1.25T$

$20\,sec = T_q$

NEED TO FIND LOCATION OF q FOR WHEN P REACHES MAXIMUM SPEED.

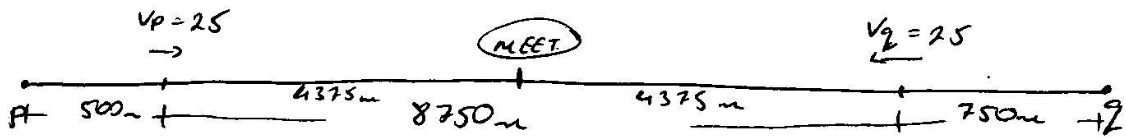
$u = 25$
$v = 25$
$a = 0$
$s = ?$
$T = 20$

$s = uT + \frac{1}{2}aT^2$

$s = 25(20) + \frac{1}{2}(0)(20)^2$

$s = 500m$

SO AFTER 40sec, P HAS TRAVELLED 500m AND
q HAS TRAVELLED 750m.



SINCE THEY ARE TRAVELLING AT THE SAME SPEED, THEY WILL MEET IN THE MIDDLE.

DIST: 4375m

SPEED: 25m/s

$T = \frac{\text{DIST}}{\text{SPEED}}$

$T = \frac{4375}{25} = 175$ sec.

$\therefore$ THEY MEET AT $T = 40 + 175 = 215$ sec.

P HAS TRAVELLED : $500 + 4375 = 4875$m

q HAS TRAVELLED : $750 + 4375 = 5125$m.

(ii) TO MEET IN THE MIDDLE, P TRAVELS 5000m.

500m ACCELERATING IN 40sec.

4500m AT 25m/s IN $\underline{180\text{sec.}}$

220sec.

q TRAVELS 5000m

250m ACCELERATING IN 20sec.

4750m AT 25m/s IN $\underline{190\text{sec}}$

210sec.

SO, P MUST BE DELAYED BY 10sec.