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Set A

BRONZE:

	x	y
s	s_x	0
u	$2u\cos\alpha$	$2u\sin\alpha$
v		
a	0	$-g$
t	t	t

a) y: R(↑): $s = ut + \frac{1}{2}at^2$

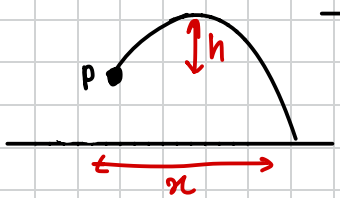
$\Rightarrow 0 = (2u\sin\alpha)t - \frac{1}{2}gt^2$

$\Rightarrow 0 = t\left(2u\sin\alpha - \frac{1}{2}g\right)$

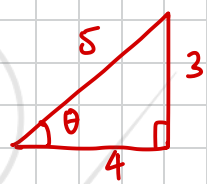
$\Rightarrow t = \frac{4u\sin\alpha}{g}$

b) RC(→): x: $s_x = ut + \frac{1}{2}at^2 = 2u\cos\alpha\left[\frac{4u\sin\alpha}{g}\right] = \frac{4u^2\sin 2\alpha}{g}$

SILVER:



	x	y
s	x	h
u	$u\cos\theta$	$u\sin\theta$
v		
a	0	$-g$
t	t	t



$\Rightarrow u\cos\theta = \frac{4}{5}u$

$u\sin\theta = \frac{3}{5}u$

a) x: $s = ut + \frac{1}{2}at^2 \Rightarrow x = \frac{4}{5}ut \Rightarrow t = \frac{5x}{4u}$ — ①

y: $s = ut + \frac{1}{2}at^2 \Rightarrow h = \frac{3}{5}u(t) - \frac{1}{2}gt^2 \Rightarrow h = \frac{3}{5}u\left(\frac{5x}{4u}\right) - \frac{1}{2}g\left(\frac{5x}{4u}\right)^2$

$\Rightarrow \frac{3}{4}x - \frac{1}{2}g\left(\frac{25x^2}{16u^2}\right) \Rightarrow \frac{3}{4}x - \frac{25gx^2}{32u^2} \Rightarrow a = \frac{3}{4}$ $b = \frac{25}{32}$

b) $U = \frac{35}{8}ms^{-1}$ $h = \frac{x}{2}$ $\Rightarrow \frac{x}{2} = \frac{3x}{4} - \frac{25gx^2}{32U^2} \Rightarrow \frac{x}{4} = \frac{25gx^2}{32U^2}$

$\Rightarrow \frac{32U^2x}{4} = \frac{25gx^2}{32U^2} \times 32U^2 \Rightarrow 8U^2x = 25gx^2$

$\Rightarrow 8U^2 = 25gx \Rightarrow x = \frac{8U^2}{25g}$

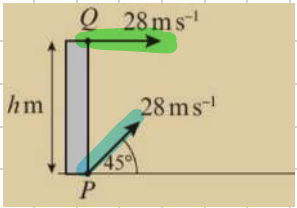
$\Rightarrow x = 40m \Rightarrow h = \frac{x}{2} = 20m$

v_x: $v = u + at \Rightarrow v = u\cos\theta = \frac{4}{5}(35) = 28\ ms^{-1}$

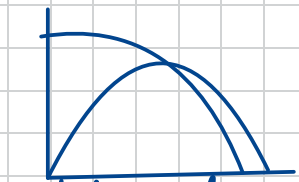
v_y: $v^2 = u^2 + 2as \Rightarrow v^2 = \frac{3}{5}(35) - 2(9.8)(20) \Rightarrow v^2 = 49$ $v = 7ms^{-1}$

$\sqrt{v_x^2 + v_y^2} \rightarrow$ Speed $= \sqrt{28^2 + 7^2} = 7\sqrt{17}\ ms^{-1}$

GOLD:

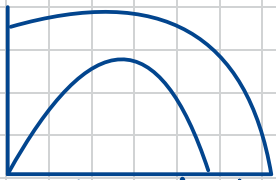


a) If h is not maximised



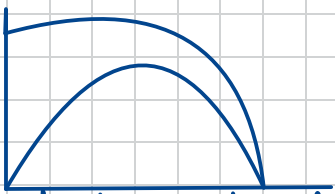
meet too early

If h is beyond maximised



not meet at all

If h is maximised



meet at ground level

P: →

	x	y
s		0 → ground to ground; displacement = 0
u	$28\cos 45°$	$28\sin 45°$
v		
a	0	$-g$
t	t_p	t_p

y: $s = ut + \frac{1}{2}at^2$

$0 = (28\sin 45°)t - 4.9t^2$

$-4.9t^2 + 14\sqrt{2}t = 0$

$t = 0$ or $t = \frac{20\sqrt{2}}{7}$

x: $s = ut + \frac{1}{2}at^2$

$s = 14\sqrt{2}\left(\frac{20\sqrt{2}}{7}\right) + \frac{1}{2}(0)t^2$

$s = 80$ m

So, Q also travelled 80 m horizontally.

Q: →

	x	y
s	80	h
u	28	0
v		
a	0	g
t	t_q	t_q

$t_q \neq \frac{20\sqrt{2}}{7}$; because they don't necessarily meet at the same time.

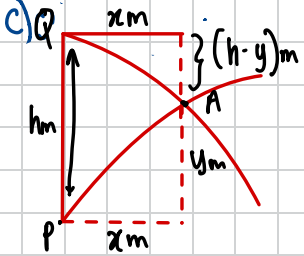
x: $s = ut + \frac{1}{2}at^2$

$80 = 28t_q \Rightarrow t_q = \frac{20}{7}$

y: $s = ut + \frac{1}{2}at^2$

$h = \frac{1}{2}(9.8)\left(\frac{20}{7}\right)^2 = 40$ m

b) The arrows will reach the point of intersection at different times.

c) 

P: →

	x	y
s	x	y
u	28cos45°	28sin45°
v		
a	0	-g
t	t_1	t_1

$x: s = ut + 0.5at^2 \Rightarrow x = 14\sqrt{2}t_1$

$\Rightarrow t_1 = \frac{x}{14\sqrt{2}}$ — ①

$y: s = ut + \frac{1}{2}at^2$

$y = 14\sqrt{2}(t_1) - 4.9t_1^2$

$y = 14\sqrt{2}\left(\frac{x}{14\sqrt{2}}\right) - 4.9\left(\frac{x}{14\sqrt{2}}\right)^2$

$\Rightarrow y = x - \frac{1}{80}x^2$ — ②

Q: →

	x	y
s	x	h-y
u	28	0
v		
a	0	g
t	t_2	t_2

$x: s = ut + \frac{1}{2}at^2$

$\Rightarrow x = 28t_2 \Rightarrow t_2 = \frac{x}{28}$ — ③

$y: s = ut + \frac{1}{2}at^2 \Rightarrow h - y = \frac{1}{2}(g)(t_2)^2 \Rightarrow h - y = 4.9\left(\frac{x}{28}\right)^2$

$\Rightarrow y = h - \frac{1}{160}x^2$ — ④

Equate ② and ④

$x - \frac{1}{80}x^2 = h - \frac{1}{160}x^2$

$\Rightarrow -\frac{1}{160}x^2 + x - h = 0$ (quadratic equation)

$\frac{1}{160}x^2 - x + h = 0 \Rightarrow a = \frac{1}{160} \quad b = -1 \quad c = h$

$\Rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \Rightarrow x = \frac{-(-1) \pm \sqrt{(-1)^2 - 4\left(\frac{1}{160}\right)h}}{2\left(\frac{1}{160}\right)}$

$\Rightarrow x = \frac{1 \pm \sqrt{1 - \frac{1}{40}h}}{\frac{1}{80}} \Rightarrow x = 80\left(1 \pm \sqrt{1 - \frac{1}{40}h}\right)$

$\Rightarrow x = 80 \pm 80\sqrt{\frac{1}{400}(400 - 10h)} \Rightarrow x = 80 \pm 80 \times \frac{1}{\sqrt{400}}\sqrt{400 - 10h}$

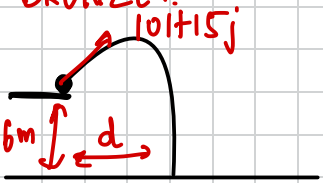
$\Rightarrow x = 80 \pm 4\sqrt{400 - 10h}$

$\Rightarrow x = 80 - 4\sqrt{400 - 10h}$ (It is the first intersect point so reject $80 + 4\sqrt{400 - 10h}$)

$\Rightarrow x = 80 - 4\sqrt{400 - 10h}$

SET: B.

BRONZE:



	x	y
s	d	6
u	10	15
v	v	v
a	0	10
t	t	t

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

$\Rightarrow v^2 = 15^2 + 2(-10)(6)$

$v^2 = 345 \quad v = \sqrt{345}\ ms^{-1}$

$x: v = u + at$

$v = 10 + 0(t) \Rightarrow v = 10\,ms^{-1}$

$\Rightarrow \sqrt{(\sqrt{345})^2 + 10^2} = \sqrt{445} = 21.1\,ms^{-1}$ (3SF)

b) $v_x = 10$; $v_y = u - at \Rightarrow 15 - 10t$.

$\Rightarrow$ Speed: $\sqrt{v_x^2 + v_y^2} = \sqrt{10^2 + (15-10t^2)} < 15$

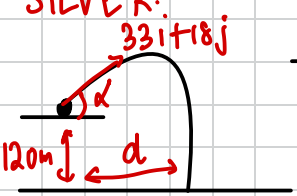
$\Rightarrow 100 + (15 - 10t^2) < 225 \Rightarrow 15 - 10t^2 < 125$

$\Rightarrow -5\sqrt{5} < 15 - 10t < 5\sqrt{5}$

$t < \frac{15+5\sqrt{5}}{10}$ or $t > \frac{15-5\sqrt{5}}{10} \Rightarrow \Delta t = \frac{(15+5\sqrt{5}) - (15-5\sqrt{5})}{10}$

$\Rightarrow \frac{10\sqrt{5}}{10} = \sqrt{5}$ seconds $=$ 2.24 seconds (3.sf)

SILVER:



	x	y
s	d	120
u	33	18
v		
a	0	-10
t	t	t

a) $x: v = u + at \Rightarrow v_x = 33 + 0(t)$

$v_x = 33\,ms^{-1}$

$\Rightarrow 55 = \sqrt{v_x^2 + v_y^2} \Rightarrow 55 = \sqrt{33^2 + v_y^2}$

$\Rightarrow 55^2 - 33^2 = v_y^2 \Rightarrow v_y = 44\,ms^{-1}$

$y: v = u + at \Rightarrow v_y = 18 - gt$

$\Rightarrow 44 = 18 + 10t \Rightarrow \boxed{t = 2.6}$

$\Rightarrow s: ut + \frac{1}{2}at^2 = 18(2.6) + \frac{1}{2}(10)(2.6)^2 = 80.6\,m$

$\Rightarrow +120 - 80.6 =$ 39.4m above ground.

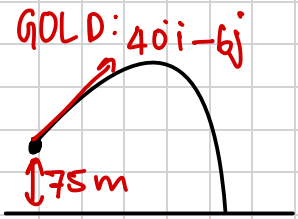
b) $y: s = ut + \frac{1}{2}at^2 \Rightarrow 120 + 18t - \frac{1}{2}gt^2 = 0 \Rightarrow 5t^2 - 18t - 120 = 0$

$\Rightarrow t = 7.019\ldots$ or ~~$t = -3.419\ldots$~~

$\Rightarrow v_y = u + at \Rightarrow 18 - 10(7.019\ldots) = -52.1 \text{ m/s}$.

$v_x = 33 \text{ ms}^{-1}$

$\tan\theta = \frac{v_y}{v_x} = \frac{52.1\ldots}{33} = \arctan\left(\frac{2\sqrt{681}}{33}\right) = 57.7^\circ$ (3sf)



	x	y
s	d	−75
u	40	−6
v		
a	0	−g
t	t	t

$x: v = u + at \Rightarrow v = 40 \text{ ms}^{-1}$

$y: v^2 = u^2 + 2as \Rightarrow (-6)^2 + 2(-g)(-75)$

$\Rightarrow v^2 = 1536 \Rightarrow v = 16\sqrt{6}$

$\Rightarrow$ Speed: $\sqrt{40^2 + (16\sqrt{6})^2} = 56 \text{ ms}^{-1}$

b) $y: s = ut + \frac{1}{2}at^2 \Rightarrow -75 = -6t - 5t^2 \Rightarrow 5t^2 + 6t - 75 = 0$

$t = 3.3191 \Rightarrow x: s = ut + \frac{1}{2}at^2 \Rightarrow s = 40 \times 3.3191\ldots$

$\Rightarrow s = 132.76734\ldots$ $d = \sqrt{(132.76\ldots)^2 + (75^2)} = 152.4\ldots \Rightarrow 152 \text{ m (3sf)}$

c) $5i - 4j \Rightarrow \sqrt{25+16} = \sqrt{41} \Rightarrow d = \left[\frac{5}{\sqrt{41}}, \frac{-4}{\sqrt{41}}\right]$

$\Rightarrow v = 40i + v_y j \Rightarrow \frac{v_y}{v_u} = -\frac{4}{5} \Rightarrow \frac{v_y}{40} = -\frac{4}{5} \Rightarrow v_y = -32 \text{ ms}^{-1}$

$\Rightarrow v_y = u_y + at \Rightarrow -32 = -6 - 10t \Rightarrow t = 2.6 \text{s}$

$\Rightarrow s = 75 + (-6)(2.6) - \frac{1}{2}(10)(2.6^2) = 25.6 \text{m}$ above the ground

d) $v^2 = u^2 + 2as$; $x: v = u + at \Rightarrow v = 40 \quad u = 6 \quad a = 10$

$\Rightarrow (-40^2) = (-6^2) - 2(10)s \Rightarrow 1564/20 = s \Rightarrow s = 78.2 > 75$

$\Rightarrow$ the particle hits the ground before achieving a velocity $(40i - 40j) \text{ ms}^{-1}$