OCR Maths M2

Topic Questions from Papers

Projectiles

Answers

1		$v^2 = 2x9.8x10$	M1		energy:$\frac{1}{2}mv^2=\frac{1}{2}mu^2 + mgh$	
		v = 14	A1		$\frac{1}{2}v^2 = \frac{1}{2}.36 + 9.8x10$	
		speed = $\sqrt{(14^2 + 6^2)}$	M1		(must be 6^2) $v^2 = 36+196=232$	
		speed = 15.2 ms^{-1}	A1			
		$\tan\theta = 14/6$	M1		$\cos^{-1}(6/15.2)$ etc	
		θ=66.8°(below) horiz.	A1	6	or 23.2° to the vertical	**6**

(Q2, June 2005)

2	(i)	$x = 49\cos\theta . t$	B1			
		$y=49\sin\theta.t - \frac{1}{2}.9.8.t^2$	B1			
		$y=x\tan\theta - 4.9x^2/49^2.\cos^2\theta$	M1		aef (eliminating t)	
		$y=x\tan\theta – x^2(1+\tan^2\theta)/490$	A1	4	AG	
	(ii)	$30 = 70\tan\theta – 10(1+\tan^2\theta)$	M1			
		$\tan\theta=(70\pm\sqrt{3300})\div20$	M1		(6.37/0.628)	
		81.1°	A1		θ_1 or θ_2	
		32.1°	A1	4	"	
	(iii)	$x^2 (1+\tan^2\theta)/490 = x\tan\theta$	M1		set y = 0	
		$x = 490\tan\theta/(1+\tan^2\theta)$	A1			
		x = 75.0	A1			
		x = 221 (220.6)	A1			
		d = 146 m	A1 √	5	√	**13**
	(iii)	Alternatively (1st 2 marks)				
		t=49sinθ/4.9 and (9.88/5.31) x=49cosθ.t	M1		s=ut+½at² and x=49cosθ.t or $R = u^2\sin2\theta/g$ (precise)	
		$x = 490\sin\theta\cos\theta$	A1		$245\sin2\theta$	

(Q8, June 2005)

3	(i)	$0 = 50 \sin25° t – 4.9t^2$	M1		or 0=50sin25° - 9.8t &2t :2x2.16	
			A1			
		t = 4.31 s	A1	3		
	(ii)	d = 50cos25° x 4.31	M1		or $u^2\sin(2x25°)/g$	
		195 m	A1√	2	√ 50cos25° x their t	**5**

(Q2, Jan 2006)

4	(i)	x = 7t	B1			
		y = - 4.9t^2 or -½gt^2	M1		some attempt at vertical motion	
			A1		sc y=xtanθ −gx^2 /(2V^2cos^{2}θ)	
		y = - x^2/10 **AG** (no fiddles)	A1	4	with θ=0 M1 then A1 (max = 2)	
	(ii)	-20 = -x^2/10	M1		or t=√(20/4.9) & x=7t	
		14.1 m	A1	2	sc B1 for 14.1 after wrong work	
	(iii)	½mv^2 = ½$m7^2$ + mgx20 n.b. v^2 =u^2	M1		**OR** v_h = 7 (B1)	
		+2as gets M0	A1		v_v = ±19.8 (B1) 14√2,2√98 etc	
		v = 21 ms^{-1}	A1		v = 21 (B1)	
		dy/dx = -2x/10 & tanθ	M1		**OR** tanθ = 19.8/7 or	
			A1		cosθ=7/21 or sinθ=19.8/21	
		70.5° to horizontal	A1	6	or 19.5° to vertical	**12**

(Q6, Jan 2006)

5	(i)	vsin50°	B1		initial vertical component	
		0=v^2sin^{2}50°-2x9.8x13 (must be 13)	M1		or mx9.8x13 = ½m(vsin50°)^2	
		v = 20.8 ms^{-1}	A1	3	sin/cos mix ok for above M1	
	(ii)	45 = vcos50°.t	M1		see alternative below	
		t = 3.36 √their v (3.13 for v=22.4)	A1√		other methods include other t_s	
		s = vsin50° x t - ½ x 9.8 x t^2	M1		ignore ht adjustments	
			A1		can be their v and their t	
		s = – 1.6 to – 2.0 inclusive (– 1.68)	A1		can be implied from next A1	
		ht above ground = 0.320 m	A1	6		
	(iii)	v_v = vsin50° - 9.8xt	M1		or v_v^2=2g(15-their ans to ii)	
		v_v = -17.0 √their v,t(-13.5 for 22.4)	A1√		√ above for v_v	
		speed=√(v_v^2+(vcos50°)^2)	M1		or ½mv^2 – mgx1.68 =	
		speed = 21.6 ms^{-1} √ their v and v_v (19.7 for v = 22.4)	A1√	4	½mx20.8^2 (4 marks) M1/A1√ s,v /M1 solve/ A1 √	**13**
	(ii)	y = xtanθ −gx^2/2v^2cos^{2}θ	B1		**Alternative 1st 5 marks**	
		y=45tan50°-9.8.45^2/2.v^2cos^{2}50°	M1		substitute v and 50° and x=45	
			A1		can be their v	
		calculate y	M1			
		y = – 1.6 to – 2.0 inclusive	A1		should be – 1.68	

(Q7, June 2006)

6	(i)	$v_v = 42\sin30°$ (=21)	B1			
		$0 = 21^2 - 2x9.8xh$	M1			
		$h = 22.5$	A1	3		
	(ii)	$v_h = 42\cos30°$ (=36.4)	B1			
		$v_v = \pm v_h \times \tan10°$	M1			
		$v_v = \pm6.41$ or $21\sqrt{3}\tan10°$	A1		or $42\cos30°.\tan10°$	
		$-6.41 = 42\sin30° - 9.8t$	M1	**	must be –6.41(also see "or" x 2)	
		$t = 2.80$	A1	**		
		$y=42\sin30°x2.8 - 4.9x2.8^2$	M1	**		
		$y = 20.4$	A1√	**	√ their t	
		$x = 42\cos30° \times 2.80$	M1			
		$x = 102$	A1√		√ their t	
		$\sqrt{(x^2 + y^2)}$	M1			
		$d = 104$	A1	11		
	or	$6.41^2 = 21^2 + 2 \times -9.8s$	M1	**	vert dist first then time	
		s = 20.4	A1	**		
		$20.4 = 21t + ½. -9.8t^2$	M1	**		
		$t = 2.80$	A1	**		
	or	$22.5 - s$ and $6.41^2=2x9.8s$	M1	**	dist from top (s = 2.096)	
		$y = 20.4$	A1	**		
		22.5 & $2.1 = ½.9.8t^2$	M1	**	2 separate times (2.143, 0.654)	
		$t = 2.80$	A1	**	2.143 + 0.654	**14**
		alternatively				
	(ii)	$y = x/\sqrt{3} - x^2/270$ aef	B1		$y=x\tan30°-9.8x^2/2.42^2.\cos^2 30°$	
		$dy/dx = 1/\sqrt{3} - x/135$	M1		for differentiating	
			A1		aef	
		$dy/dx = -\tan10°$	M1		must be $-\tan10°$	
		$1/\sqrt{3} - x/135 = -\tan10°$	A1			
		solve for x	M1			
		$x = 102$	A1√		√ on their dy/dx	
		$y = x/\sqrt{3} - x^2/270$	M1			
		$y = 20.4$	A1√		√ their x	
		$\sqrt{(x^2 + y^2)}$	M1			
		$d = 104$	A1	(11)		

(Q8, Jan 2007)

7	$0 = 12\sin27°t - 4.9t^2$ any correct.	M1	**or** $R = u^2\sin2\theta/g$ (B2)
	$t = 1.11$ …..method for total time	A1	correct formula only
	$R = 12\cos27° \times t$	M1	$12^2 \times \sin54° / 9.8$ sub in values
	11.9	A1 **4**	11.9 **4**

(Q2, June 2007)

8 (i)	$x = 7t$	B1	
	$y = 21t - 4.9t^2$	M1	**or** – g/2
		A1	
	$y = 21.x/7 - 4.9\,x^2/49$	M1	
	$y = 3x - x^2/10$	A1 **5**	**AG**
(ii)	$-25 = 3x - x^2/10$ (must be -25)	M1	**or** method for total time (5.26)
	solving quadratic	M1	**or** 7 x total time
	36.8 m	A1 **3**	**8**

(Q4, June 2007)

9 (i)	12 x cos55° 6.88 m s^{-1}	M1 A1 **2**	

(Q1, Jan 2008)

10(i)	$0 = (175\sin\theta)^2 - 2x9.8x650$ $\theta = 40.2°$	M1 A1 A1 **3**	
(ii)	Attempt at t_1 , t_2 , t_{top} or t_{total} 5.61, 23.65, 14.63, 29.26 $t_2 - t_1$ or $2(t_{top} - t_1)$ or $t_{total} - 2t_1$ time difference = 18.0	M1 A1 M1 A1 A1 **5**	$650 = 175\sin55°.t - 4.9t^2$ etc
(iii)	$v_h = 175\cos55°$ (100.4) $v_v = 175\sin55° - 9.8 \times 5.61$ speed = $\sqrt{(88.4^2 + 100.4^2)}$ 134 m s^{-1}	B1 M1 M1 A1 **4**	or KE ½mv^2 (B1) PE mx9.8x650 $v = \sqrt{(175^2 - 2x9.8x650)}$ **12**

(Q7, Jan 2008)

11(i)	$0 = 35\sin\theta \times t - 4.9t^2$	M1	$R=u^2\sin2\theta/g$ only ok if proved
	$t = 35\sin\theta/4.9$ $\quad 50\sin\theta/7$ $R = 35\cos\theta \times t$ $\quad$ aef	A1 B1	or $70\sin\theta/g$ aef their t
	$R = 35^2\sin\theta.\cos\theta/4.9$	M1	eliminate t
	$R = 125\sin2\theta$	A1 **5**	**AG**
(ii)	$110 = 125\sin2\theta$ $\theta = 30.8°$ or 59.2° t = 3.66 s or 6.13 s	M1 A1+1 A1+1 **5**	**10**

(Q4, June 2008)

12 (ii)	$v_h = 2$ $v_v^2 = 2 \times 9.8 \times 4$ $v_v = 8.85$ $\quad (14\sqrt{10}/5)$	B1 M1 A1	or (B1) ½$mx2^2$ (B1) ½mxv^2 (B1) mx9.8x4
	speed = $\sqrt{(8.85^2 + 2^2)}$ 9.08 m s^{-1} $\tan^{-1}(8.85/2)$ 77.3° to horizontal	M1 A1 M1 A1 **7**	$v = \sqrt{(2^2 + 2x9.8x4)}$ or $\cos^{-1}(2/9.08)$ 12.7° to vertical **13**

(Q7, June 2008)

13	$(20 \sin \theta)^2 = 2 \times 9.8 \times 17$	M1	or B2 for max ht = $v^2\sin^2\theta/2g$
		A1	
	$\sin \theta = \sqrt{(2 \times 9.8 \times 17)} \div 20$	M1	subst. values in above
	$\theta = 65.9°$	A1 **4**	**4**

(Q1, Jan 2009)

14 (i)	$x = v\cos\theta\, t$	B1	
	$y = v\sin\theta\, t - \frac{1}{2} \times 9.8\, t^2$	B1	or g
	substitute $t = x/v\cos\theta$	M1	
	$y = x\tan\theta - 4.9x^2/v^2\cos^2\theta$	A1 **4**	**AG**
(ii)	Sub $y = -h$, $x = h$, $v = 14$, $\theta = 30$	M1	signs must be correct
	$-h = h/\sqrt{3} - h^2/30$	A1	aef
	solving above	M1	
	$h = 47.3$	A1 **4**	
(iii)	$v_v^2 = (14\sin 30°)^2 - 2 \times 9.8 \times (-47.3)$	M1	$14\cos 30° \, t = 47.3$ ft & $v_v = 14\sin 30° - 9.8t$
	(double negative needed) ft their -47.3	A1 ft	$t = 3.90$ (or $dy/dx = 1/\sqrt{3} - x/15$ etc ft)
	$v_v = \pm 31.2$	A1	$v_v = \pm 31.2$ ($\tan\alpha = 1/\sqrt{3} - 47.3/15$)
	$\tan^{-1}(31.2/14\cos 30°)$	M1	$\tan^{-1}(31.2/14\cos 30°)$
	$\alpha = 68.8°$ below horiz/21.2° to d'vert.	A1 **5**	68.8°/…..
(iv)	$\frac{1}{2}mx14^2 + mx9.8x47.3 = \frac{1}{2}mv^2$	M1	ft $(12.1^2 + 31.2^2)$
	$v = 33.5$	A1 **2**	33.5 **15**

(Q6, Jan 2009)

15 (i)	$9 = 17\cos 25° \times t$	M1	B1 $y = x\tan\theta - 4.9x^2/v^2\cos^2\theta$
	$t = 0.584$ (or $9/17\cos 25°$)	A1	M1/A1 $y = 9\tan(-25°) - 4.9 \times 9^2/17^2\cos^2 25°$
	$d = 17\sin 25° \times 0.584 + \frac{1}{2} \times 9.8 \times 0.584^2$ (d = *ht* lost (5.87)	M1	
		A1	A1 y = -5.87
	$h = 2.13$	A1 **5**	2.13
(ii)	$v_h = 17\cos 25°$ (15.4)	B1	M1/A1 $dy/dx =$
	$v_v = 17\sin 25° + 9.8 \times 0.584$ or $v_v^2 = (17\sin 25°)^2 + 2 \times 9.8 \times 5.87$	M1	$\tan\theta - 9.8x/v^2\cos^2\theta$
	$v_v = 12.9$	A1	A1 $dy/dx = -0.838$
	$\tan\theta = 12.9/15.4$	M1	M1 $\tan^{-1}(-.838)$
	$\theta = 40.0°$ below horizontal	A1 **5**	or 50.0° to vertical
(iii)	speed $= \sqrt{(12.9^2 + 15.4^2)}$	M1	(20.1)
		A1	
	$\frac{1}{2}mv^2 = \frac{1}{2}m \times 20.1^2 \times 0.7$	M1	NB 0.3 instead of 0.7 gives 11.0 (M0)
	$v = 16.8$ m s^{-1}	A1 **4**	**14**

(Q7, June 2009)

16 (i)	$30^2 = V_1^2 \sin^2\theta_1 - 2\times9.8\times250$	M1	$\frac{1}{2}mV_1^2 = \frac{1}{2}m\,50^2 + m\times9.8\times250$
	$V_1^2 \sin^2\theta_1 = 5800$ AEF	A1	
	$V_1 \cos\theta_1 = 40$	B1	
	$V_1 = 86.0$	A1	**AG**
	$\theta_1 = 62.3°$	A1 **[5]**	**AG**
(ii)	$0 = \sqrt{5800}\, t_p - 4.9t_p^2$	M1	$30 = V_1 \sin\theta_1 - 9.8t$
	$t_p = 15.5$	A1	
			$t = 4.71$
	$-\sqrt{5800} = 30 - 9.8t_q$	M1	
	$t_q = 10.8$	A1 **[4]**	
(iii)	$R = 40\times15.5$	M1	
	$R = 621$	A1	(620, 622)
	$V_2 \cos\theta_2 \times 10.8 = 621$	B1	$V_2 \cos\theta_2 = 57.4$
	$0 = V_2 \sin\theta_2 \times 10.8 - 4.9 \times 10.8^2$	M1	
	$V_2 \sin\theta_2 = 53.1$ or 53.0	A1	(52.9,53.1)
	Method to find a value of V_2 or θ_2	M1	
	$\theta_2 = 42.8°$	A1	42.6° to 42.9°
	$V_2 = 78.2$ m s^{-1} or 78.1 m s^{-1}	A1 **[8]**	or 78.1° **17**

(Q6, Jan 2010)

17	$v^2 = 2 \times 9.8 \times 10$	M1	Using $v^2 = u^2 + 2as$ with $u = 0$
	$v = 14$ m s^{-1}	A1	
	speed $= \sqrt{(7^2 + 14^2)}$	M1	Method to find speed using their "v"
	15.7 or $7\sqrt{5}$ m s^{-1}	A1	
	$\tan^{-1}(14/7)$ or $\tan^{-1}(7/14)$	M1	Method to find angle using their "v"
	63.4° to the horizontal	A1 **6**	26.6° to vertical **6**

(Q1, June 2010)

18 (i)	R = 0.2 x 9.8 x cos30° (= 1.70)	B1		
	F = 0.1 x 9.8 x cos30° (= 0.849) FT	B1		FT on their R, but not R =0.2g
		M1		Use of conservation of energy
	½ x 0.2 x 11^2 - ½ x 0.2 v^2 =	A1		
	0.2 x 9.8 x 5sin30 + 5 x 0.849	A1		
	v = 5.44 m s^{-1}	A1	**6**	**AG**
Or	F + 0.2gsin30 = ±0.2a	M1		Use of N2L, 3 terms
last 4	a = ±9.1	A1		
marks	$v^2 = 11^2 + 2$ x a x 5	M1		Complete method to find v
of (i)	v = 5.44 m s^{-1}	A1		
(ii)	t = 5cos30°/5.44cos30°	M1		time to lateral position over *C*
	t = 0.919 s	A1		
	u = 5.44sin30° (= 2.72)	B1		
	$s = 2.72 \times 0.919 - 4.9 \times 0.919^2$	M1		
	s = -1.6 (or better)	A1		Ht dropped
	Ht drop to *C* = 5sin30° = 2.5 m	B1		
	Ball does not hit the roof	A1	**7**	**13**
Or	$y = x\tan\theta - gx^2 \sec^2\theta/2V^2$	B1		
first	substitute values	M1		
5	V = 5.44 θ = 30° x = 5cos30°	A1		all 3 correct
marks	$y = 2.5 - 9.8x25x3/4x4/3 / (2x5.44^2)$	A1		
of (ii)	y = -1.6 (or better)	A1		
OR (ii)	u = 5.44sin30° (= 2.72)	B1		
	$-2.5 = 5.44\sin30t - 4.9t^2$	M1		
		A1		aef
	t = 1.04	A1		time to position level with *AC*
	x = 5.44cos30 x 1.04 = 4.9 (or better)	A1		
	Horizontal distance from B to C =			
	5cos30 = 4.3(or better)	B1		
	Ball does not hit the roof	A1	**7**	
OR (ii)	$y = x\tan\theta - gx^2 \sec^2\theta/2V^2$	B1		
	substitute values	M1		
	$-2.5 = 0.577x - 0.221x^2$	A1		aef
	Attempt to solve quadratic for x	M1		
	x = 4.9 (or better)	A1		
	Horizontal distance from B to C =			
	5cos30 = 4.3 (or better)	B1		
	Ball does not hit the roof	A1	**7**	
OR (ii)	u = 5.44sin30° = 2.72	B1		
	$-2.5 = 5.44\sin30t - 4.9t^2$	M1		
		A1		aef
	t = 1.0 (or better)	A1		time to position level with *AC*
	T = 5cos30°/5.44cos30°	M1		
	T = 0.92 (or better)	A1		time to lateral position over *C*
	Ball does not hit the roof	A1	**7**	

(Q7, June 2010)

19	**(i)**		$0 = (14\sin30)^2 - 2gh$ $h = 2.5$ m	M1 A1 **[2]**	$h = (14\sin30)x1/1.4 - g(1/1.4)^2/2$ or use $(u^2\sin^2\theta)/2g$
	(ii)		$0.4x15 = 0.4(14\cos30) + I$ $I = 1.15$	M1 A1 A1 **[3]**	Impulse = change in momentum Not 14 or 0 for horizontal speed before impulse aef
	(iii)		$v^2 = (14\sin30)^2 + 15^2$ $v = 16.6$ ms^{-1} $\tan\theta = 14\sin30/15$ OR $\tan\psi = 15/14\sin30$ $\theta = 25(.0)°$ OR $\psi = 65(.0)°$	M1 A1 M1 A1 **[4]**	Not $(14\sin30)^2 + (14\cos30)^2$ Allow $\sqrt{274}$ Correct trig to find an appropriate angle; not 14cos 30 for 15
	(iv)		$t = 14\sin30/g$ (= 1/1.4 = 0.7142..) $T = 1.43$ s $R = 14\cos30/1.4 + 15/1.4$ $R = 19.4$ m	M1 A1 M1A1 A1 **[5]**	Rise or fall time (not to be given in (i)) Accept 10/7 $(14^2\sin(2x30) + 16.6^2\sin(2x25))/2g$. 14 resolved, 15 not

(Q6, Jan 2011)

20 i	$x = (7\cos30)t$ $y = (7\sin30)t - gt^2/2$ $y = x\tan30 - gx^2/(2x7^2\cos^230)$	B1 B1 M1 A1 [4]	 Attempt to eliminate t $y = x/\sqrt{3} - 2x^2/15$ or $y = 0.577x - 0.133x^2$ aef
ii	$2x^2/15 - x/\sqrt{3} + 0.6 = 0$ or $9.8t^2 - 7t + 1.2 = 0$ $x = 1.73$ m or $\sqrt{3}$ m 2.6(0) m or $3\sqrt{3}/2$ m	M1 M1 A1 A1 [4]	Create a 3 term Q.E. in x or t with y = 0.6 Solve 3 term Q.E. for x or t
iii	$v^2 = (7\sin30)^2 - 2x9.8x0.6$ $v = 0.7$ ms^{-1} $\tan\theta = 0.7/(7\cos30)$ $\theta = 6.59°$ to horizontal or 83.4° to vertical **OR** Attempt to differentiate equation of trajectory $\tan30 - gx/(7^2\cos^230)$ Substitute $x = \sqrt{3}$ and equate to $\tan\theta$ $\theta = 6.59°$ to horizontal or 83.4° to vertical	M1 A1 M1 A1 [4] M1 A1 M1 A1 [4]	Using $v^2 = u^2 - 2gs$ with u a component of 7; can find t first from their x in (i), and then use $v = u + at$. Use component of 7 Allow $1/\sqrt{3} - 4x/15$ or $y' = 0.577 - 0.267x$

(Q5, June 2011)

21			$v_x = 40\cos35$ $v_y = 40\sin35 - 9.8 \times 3$ $v = \sqrt{32.8^2 + 6.46^2}$ or $\tan\theta = 6.46/32.8$ $v = 33.4$ ms^{-1} $\theta = 11.1°$ below horizontal	B1 B1 M1 A1 A1 [5]	Expect 32.8, need not be evaluated. Expect –6.46, need not be evaluated. Use of Pythagoras or relevant trig on cv(v_x) and cv(v_y) AEF; allow 11.2

(Q1, Jan 2012)

22	(i)		*For P* $4.9t^2 = 60$ $t = 3.5(0)$ *For Q* $0 = 25\sin\theta \times t - ½ \times 9.8 \times t^2$ $\theta = 43.3$ $PQ = (25\cos\theta - 15) \times t_c$ $= 11.2$	M1 A1 M1 A1 M1 A1 [6]	Signs must be consistent. aef
	(ii)		$25\cos\theta\,(t) = 15(t)$ and solving for θ $\theta = 53.1$ *For Q* $s_{y1} = 25\sin\theta \times t - ½ \times 9.8 \times t^2$ *For P* $s_{y2} = \pm ½ \times 9.8 \times t^2$ Using $s_{y1} + s_{y2} = 60$ Solving for t $t = 3$ $v = 25\sin\theta - 9.8 \times 3$ $v = -9.4$ therefore falling.	M1 A1 B1 B1 *M1 M1dep* A1 M1 A1 [9]	Equating horizontal components of velocity (or displacement) and solving for θ. Other methods include finding time to max height for Q.
OR	(ii)		$25\cos\theta\,(t) = 15(t)$ and solving for θ $\theta = 53.1$ *For Q* $y = x\tan\theta - \frac{gx^2}{2\times(25)^2\cos^2\theta}$ *For P* $y = (60-)\frac{gx^2}{2\times(15)^2}$ Equate y and solve for x Use $x = u\cos\theta t$ to find t $t = 3$ $v = 25\sin\theta - 9.8 \times 3$ $v = -9.4$ therefore falling.	M1 A1 B1 B1 *M1 M1dep* A1 M1 A1 [9]	Equating horizontal components of velocity (or displacement) and solving for θ. Must include 60. Other methods include finding time to max height for Q.

(Q7, Jan 2012)

23	(i)		$½ \times 9.8 \times t^2 = 0.2$ $t = 0.2(02)$ $s = 14.4 \times t_c$ $s = 2.91$ m	M1 A1 M1 A1 **[4]**	Using SUVAT to find t, consistent signs for g and 0.2 aef Using their value of t
		OR	Use equation of trajectory $-0.2 = x\tan0 - gx^2\sec^2 0/(2\text{x}14.4^2)$ Solve quadratic for x $x = 2.91$	M1 A1 M1 A1 **[4]**	B1 for correct equation of the trajectory seen anywhere but award in part (ii) unless different method seen; consistent signs for g and 0.2
	(ii)		$U\sin15 \times t - ½ \times 9.8 \times t^2 = -0.2$ $U\cos15 \times t = 6$ Eliminate t Attempt to solve to find U $U = 10.2$ ms^{-1}	*M1 A1 B1 Dep*M1 Dep*M1 A1 **[6]**	Using $s = ut + ½\,at^2$ with $s = \pm0.2$ and $a = \pm g$ Eliminate U Attempt to solve to find $t(=0.607)$
		OR	$y = x\tan\theta - gx^2\sec^2\theta/2U^2$ Substitute values for y, x, θ $-0.2 = 6\tan15 - g.6^2\sec^2 15/2U^2$ Attempt to solve for U $U = 10.2$ ms^{-1}	*B1 Dep*M1 A1 Dep*M2 A1 **[6]**	

(Q4, June 2012)

24	**(i)**		x = ucosθ t y = usinθ t – ½gt^2 Eliminate t Get y = xtanθ –gx^{2}sec^{2}θ/2u^2 **[AG]**	B1 B1 M1 A1 **[4]**	www	
	(ii)		Substitute x = 22, y = -2.1 and u = 14 Use sec^{2}θ = 1 + tan^{2}θ Tidy to 12.1tan^{2}θ – 22tanθ + 10 = 0 **[AG]** Solve QE for tanθ θ = 42.3	M1 B1 A1 M1 A1 **[5]**	May start again of course www allow in radians (0.738)	
	(iii)		t = 22/14cosθ t = 2.12s	M1 A1 **[2]**	May work vertically, but must solve for t to get M1	

(Q7, Jan 2013)

25		**(i)**	$u\cos\theta = 14\cos 20$	B1	U_x =13.15... Horizontal component of initial velocity, could use U_x
				M1	Complete method to find vertical component of initial velocity, could use U_y
			$-14\sin 20 = u\sin\theta - 1.4g$	A1	U_y = 8.9317……
			$u^2 = (1.4g - 14\sin 20)^2 + (14\cos 20)^2$	M1	Method to find u
			$u = 15.9$ **AG**	A1	cwo
			$\tan\theta = (1.4g - 14\sin 20)/14\cos 20$	M1	Method to find θ or a relevant angle
			$\theta = 34.2$	A1	SC M1A1 for $-\tan 20 = (u\sin\theta - 1.4g)/u\cos\theta$ **OR** $14^2 = (u\sin\theta - 1.4g)^2 + (u\cos\theta)^2$ B1M1A1 for both.
				[7]	
		(ii)		M1	Method to find Level of P above A
			$\frac{1}{2}m(15.9^2 - 14^2) = mgy$	A1	
			$y = 2.9$ m	A1	
				[3]	
	OR	**(ii)**		M1	Use constant acc formulae, a complete method needed.
			$(14\sin 20)^2 = (15.9\sin\theta)^2 - 2gs$ or $s = 15.9\sin\theta \times 1.4 - \frac{1}{2}g \times 1.4^2$	A1ft	ft their θ from (i). no θ value used then M1A0.
			$s = 2.9$ m	A1	
				[3]	
		(iii)	$-2.9 = v\sin 20.t - 9.8t^2/2$	B1ft	ft their 2.9
			$2.9\tan 20 = v\cos 20.t$	B1ft	ft their 2.9
			Eliminate t to obtain equation in v only	M1	Eliminate v to obtain equation in t only and solve for t
			Solve for v	M1	Substitute t to find v
			$v = 1.37$	A1	
				[5]	
	OR	**(iii)**		M2	Using equation of trajectory method.
			$-2.9 = (2.9\tan 20) \times \tan 20 - g(2.9\tan 20)^2/2v^2\cos^2 20$	A1ft	
			Solve for v	M1	
			$v = 1.37$	A1	
				[5]	
	OR	**(iii)**	$2.9/\cos 20 = \frac{1}{2}g\cos 20 \times t^2$	B1ft	
			$0 = vt - \frac{1}{2}g\sin 20 \times t^2$	B1	
			Eliminate t	M1	$t = 0.817$
			Solve for v	M1	
			$v = 1.37$	A1	
				[5]	
		(iv)	$e = 0.098$	B1ft	ft their v from **(iii)**, must be v/14.
				[1]	

(Q7, June 2013)