1. A ball is projected vertically upwards with a speed of 14.7 ms^{-1} from a point which is 49 m above horizontal ground. Modelling the ball as a particle moving freely under gravity, find

(a) the greatest height, above the ground, reached by the ball,

(4)

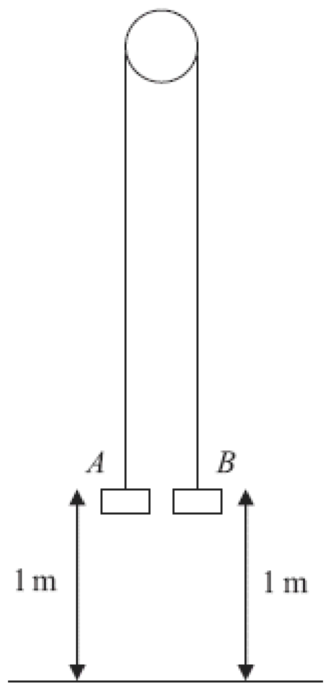
(b) the speed with which the ball first strikes the ground,

(3)

(c) the total time from when the ball is projected to when it first strikes the ground.

(3)
(Total 10 marks)

2.



Two particles A and B have mass 0.4 kg and 0.3 kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed above a horizontal floor. Both particles are held, with the string taut, at a height of 1m above the floor, as shown in the diagram above. The particles are released from rest and in the subsequent motion B does not reach the pulley.

(a) Find the tension in the string immediately after the particles are released.

(6)

(b) Find the acceleration of *A* immediately after the particles are released.

(2)

When the particles have been moving for 0.5 s, the string breaks.

(c) Find the further time that elapses until *B* hits the floor.

(9)
(Total 17 marks)

3. A particle of mass 0.8 kg is held at rest on a rough plane. The plane is inclined at 30° to the horizontal. The particle is released from rest and slides down a line of greatest slope of the plane. The particle moves 2.7 m during the first 3 seconds of its motion. Find

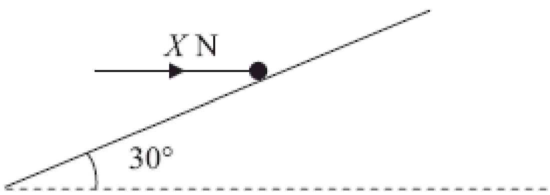
(a) the acceleration of the particle,

(3)

(b) the coefficient of friction between the particle and the plane.

(5)

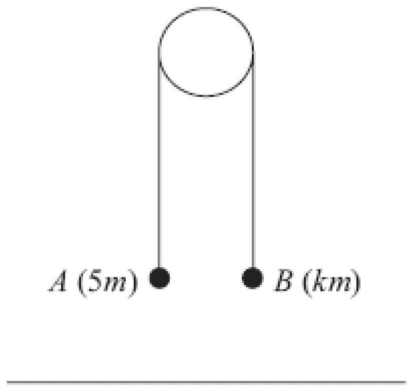
The particle is now held on the same rough plane by a horizontal force of magnitude *x* newtons, acting in a plane containing a line of greatest slope of the plane, as shown in the diagram above. The particle is in equilibrium and on the point of moving up the plane.



(c) Find the value of *X*.

(7)
(Total 15 marks)

4.



Two particles A and B have masses $5m$ and km respectively, where $k < 5$. The particles are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut, the hanging parts of the string vertical and with A and B at the same height above a horizontal plane, as shown in Figure 4. The system is released from rest. After release, A descends with acceleration $\frac{1}{4}g$.

(a) Show that the tension in the string as A descends is $\frac{15}{4}mg$.

(3)

(b) Find the value of k.

(3)

(c) State how you have used the information that the pulley is smooth.

(1)

After descending for 1.2 s, the particle A reaches the plane. It is immediately brought to rest by the impact with the plane. The initial distance between B and the pulley is such that, in the subsequent motion, B does not reach the pulley.

(d) Find the greatest height reached by B above the plane.

(7)
(Total 14 marks)

5. Three posts P, Q and R, are fixed in that order at the side of a straight horizontal road. The distance from P to Q is 45 m and the distance from Q to R is 120 m. A car is moving along the road with constant acceleration a m s^{-2}. The speed of the car, as it passes P, is u m s^{-1}. The car passes Q two seconds after passing P, and the car passes R four seconds after passing Q. Find

(i) the value of u,

(ii) the value of a.

(Total 7 marks)

6. A particle P moves with constant acceleration $(2\mathbf{i} - 5\mathbf{j})$ m s^{-2}. At time $t = 0$, P has speed u m s^{-1}. At time $t = 3$ s, P has velocity $(-6\mathbf{i} + \mathbf{j})$ m s^{-1}.

Find the value of u.

(Total 5 marks)

7. A small ball is projected vertically upwards from ground level with speed u m s^{-1}. The ball takes 4 s to return to ground level.

(a) Draw a velocity-time graph to represent the motion of the ball during the first 4 s.

(2)

(b) The maximum height of the ball above the ground during the first 4 s is 19.6 m. Find the value of u.

(3)
(Total 5 marks)

8. A train moves along a straight track with constant acceleration. Three telegraph poles are set at equal intervals beside the track at points A, B and C, where $AB = 50$ m and $BC = 50$ m. The front of the train passes A with speed 22.5 m s^{-1}, and 2 s later it passes B. Find

(a) the acceleration of the train,

(3)

(b) the speed of the front of the train when it passes *C*,

(3)

(c) the time that elapses from the instant the front of the train passes *B* to the instant it passes *C*.

(4)
(Total 10 marks)

9. A stone is thrown vertically upwards with speed 16 m s^{-1} from a point *h* metres above the ground. The stone hits the ground 4 s later. Find

(a) the value of *h*,

(3)

(b) the speed of the stone as it hits the ground.

(3)
(Total 6 marks)

10. In taking off, an aircraft moves on a straight runway *AB* of length 1.2 km. The aircraft moves from *A* with initial speed 2 m s^{-1}. It moves with constant acceleration and 20 s later it leaves the runway at *C* with speed 74 m s^{-1}. Find

(a) the acceleration of the aircraft,

(2)

(b) the distance *BC*.

(4)
(Total 6 marks)

11. A stone *S* is sliding on ice. The stone is moving along a straight horizontal line *ABC*, where *AB* = 24 m and *AC* = 30 m. The stone is subject to a constant resistance to motion of magnitude 0.3 N. At *A* the speed of *S* is 20 m s^{-1}, and at *B* the speed of *S* is 16 m s^{-1}. Calculate

(a) the deceleration of *S*,

(2)

(b) the speed of *S* at *C*.

(3)

(c) Show that the mass of *S* is 0.1 kg.

(2)

At *C*, the stone *S* hits a vertical wall, rebounds from the wall and then slides back along the line *CA*. The magnitude of the impulse of the wall on *S* is 2.4 Ns and the stone continues to move against a constant resistance of 0.3 N.

(d) Calculate the time between the instant that *S* rebounds from the wall and the instant that *S* comes to rest.

(6)
(Total 13 marks)

12. Two cars *A* and *B* are moving in the same direction along a straight horizontal road. At time $t = 0$, they are side by side, passing a point *O* on the road. Car *A* travels at a constant speed of 30 m s^{-1}. Car *B* passes *O* with a speed of 20 m s^{-1}, and has constant acceleration of 4 m s^{-2}.

Find

(a) the speed of *B* when it has travelled 78 m from *O*,

(2)

(b) the distance from *O* of *A* when *B* is 78 m from *O*,

(4)

(c) the time when *B* overtakes *A*.

(5)
(Total 11 marks)

13. A particle *P* is moving with constant acceleration along a straight horizontal line *ABC*, where *AC* = 24 m. Initially *P* is at *A* and is moving with speed 5 m s^{-1} in the direction *AB*. After 1.5 s, the direction of motion of *P* is unchanged and *P* is at *B* with speed 9.5 m s^{-1}.

(a) Show that the speed of *P* at *C* is 13 m s^{-1}.

(4)

The mass of P is 2 kg. When P reaches C, an impulse of magnitude 30 Ns is applied to P in the direction CB.

(b) Find the velocity of P immediately after the impulse has been applied, stating clearly the direction of motion of P at this instant.

(3)
(Total 7 marks)

14. A particle P of mass 2 kg is moving with speed u m s^{-1} in a straight line on a smooth horizontal plane. The particle P collides directly with a particle Q of mass 4 kg which is at rest on the same horizontal plane. Immediately after the collision, P and Q are moving in opposite directions and the speed of P is one-third the speed of Q.

(a) Show that the speed of P immediately after the collision is $\frac{1}{5}u$ m s^{-1}.

(4)

After the collision P continues to move in the same straight line and is brought to rest by a constant resistive force of magnitude 10 N. The distance between the point of collision and the point where P comes to rest is 1.6 m.

(b) Calculate the value of u.

(5)
(Total 9 marks)

15. A small ball is projected vertically upwards from a point A. The greatest height reached by the ball is 40 m above A. Calculate

(a) the speed of projection,

(3)

(b) the time between the instant that the ball is projected and the instant it returns to A.

(3)
(Total 6 marks)

16. A competitor makes a dive from a high springboard into a diving pool. She leaves the springboard vertically with a speed of 4 m s^{-1} upwards. When she leaves the springboard, she is 5 m above the surface of the pool. The diver is modelled as a particle moving vertically under gravity alone and it is assumed that she does not hit the springboard as she descends. Find

(a) her speed when she reaches the surface of the pool,

(3)

(b) the time taken to reach the surface of the pool.

(3)

(c) State two physical factors which have been ignored in the model.

(2)
(Total 8 marks)

17. A ball is projected vertically upwards with a speed u m s^{-1} from a point A which is 1.5 m above the ground. The ball moves freely under gravity until it reaches the ground. The greatest height attained by the ball is 25.6 m above A.

(a) Show that $u = 22.4$.

(3)

The ball reaches the ground T seconds after it has been projected from A.

(b) Find, to 2 decimal places, the value of T.

(4)

The ground is soft and the ball sinks 2.5 cm into the ground before coming to rest. The mass of the ball is 0.6 kg. The ground is assumed to exert a constant resistive force of magnitude F newtons.

(c) Find, to 3 significant figures, the value of F.

(6)

(d) State one physical factor which could be taken into account to make the model used in this question more realistic.

(1)
(Total 14 marks)

18. An aircraft moves along a straight horizontal runway with constant acceleration. It passes a point A on the runway with speed 16 m s^{-1}. It then passes the point B on the runway with speed 34 m s^{-1}.

The distance from A to B is 150 m.

(a) Find the acceleration of the aircraft.

(3)

(b) Find the time taken by the aircraft in moving from A to B.

(2)

(c) Find, to 3 significant figures, the speed of the aircraft when it passes the point mid-way between A and B.

(2)
(Total 7 marks)

19. A post is driven into the ground by means of a blow from a pile-driver. The pile-driver falls from rest from a height of 1.6 m above the top of the post.

(a) Show that the speed of the pile-driver just before it hits the post is 5.6 m s^{-1}.

(2)

The post has mass 6 kg and the pile-driver has mass 78 kg. When the pile-driver hits the top of the post, it is assumed that `there is no rebound and that both then move together with the same speed.

(b) Find the speed of the pile-driver and the post immediately after the pile-driver has hit the post.

(3)

The post is brought to rest by the action of a resistive force from the ground acting for 0.06 s.

By modelling this force as constant throughout this time,

(c) find the magnitude of the resistive force,

(4)

(d) find, to 2 significant figures, the distance travelled by the post and the pile-driver before they come to rest.

(4)
(Total 13 marks)

1.	(a)	$(\uparrow) v^2 = u^2 + 2as$		
		$0 = 14.7^2 - 2\text{x } 9.8 \text{ x } s$	M1 A1	
		s = 11.025 (or 11 or 11.0 or 11.03) m	A1	
		Height is 60 m or 60.0 m **ft**	A1ft	4
	(b)	$(\downarrow) v^2 = u^2 + 2as$		
		$v^2 = (-14.7)^2 + 2 \times 9.8 \times 49$	M1 A1	
		$v = 34.3$ or 34 m s^{-1}	A1	3
	(c)	$(\downarrow) v = u + at$		
		$34.3 = -14.7 + 9.8t$	M1 A1	
		$t = 5$	A1	3
		OR		
		$(\downarrow) s = ut + \frac{1}{2}at^2$		
		$49 = -14.7t + 4.9t^2$	M1 A1	
		$t = 5$	A1	3

[10]

2.	(a)	$(\downarrow) 0.4g - T = 0.4a$	M1 A1	
		$(\uparrow) T - 0.3g = 0.3a$	M1 A1	
		solving for T	DM1	
		T = 3.36 or 3.4 or 12g/35 (N)	A1	6
	(b)	$0.4g - 0.3g = 0.7a$	DM1	
		$a = 1.4$ m s^{-2}, $g/7$	A1	2
	(c)	$(\uparrow) v = u + at$		
		$v = 0.5 \text{ x } 1.4$	M1	
		$= 0.7$	A1 ft on a	
		$(\uparrow) s = ut + \frac{1}{2}at^2$		
		$s = 0.5 \text{ x } 1.4 \text{ x } 0.5^2$	M1	
		$= 0.175$	A1 ft on a	
		$(\downarrow) s = ut + \frac{1}{2}at^2$		
		$1.175 = -0.7t + 4.9t^2$	DM1 A1 ft	
		$4.9t^2 - 0.7t - 1.175 = 0$		
		$t = \dfrac{0.7 \pm \sqrt{0.7^2 + 19.6 \text{ x } 1.175}}{9.8}$	DM1 A1 cao	

$= 0.5663..\text{or } -...$

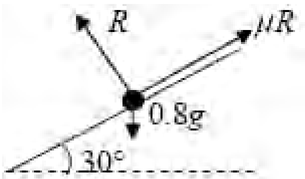
Ans 0.57 or 0.566 s — A1 cao — 9

[17]

3. (a) $s = ut + \frac{1}{2}at^2 \Rightarrow 2.7 = \frac{1}{2}a \times 9$ — M1 A1

$a = 0.6$ (m s^{-2}) — A1 — 3

(b)



↖ $R = 0.8g\cos 30°(\approx 6.79)$ — B1

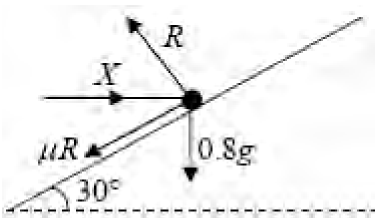
Use of $F = \mu R$ — B1

↙ $0.8g\sin 30° - \mu R = 0.8 \times a$ — M1 A1

$(0.8g\sin 30° - \mu\, 0.8g\cos 30° = 0.8 \times 0.6)$

$\mu \approx 0.51$ accept 0.507 — A1 — 5

(c)



↑ $R\cos 30° = \mu R\cos 60° + 0.8g$ — M1 A2 (1,0)

$(R \approx 12.8)$

→ $X = R\sin 30° + \mu R\sin 60°$ — M1 A1

Solving for X, $X \approx 12$ accept 12.0 — DM1 A1 — 7

<u>Alternative</u>

↖ $R = X\sin 30° + 0.8 \times 9.8\sin 60°$ — M1 A2 (1,0)

↙ $\mu R + 0.8\text{g}\cos 60° = X\cos 30°$ — M1 A1

$$X = \frac{\mu 0.8g\sin 60° + 0.8g\cos 60°}{\cos 30° - \mu\sin 30°}$$

Solving for X, $X \approx 12$ accept 12.0 — DM1 A1

[15]

4. (a) N2L A: $5mg - T = 5m \times \frac{1}{4}g$ M1 A1

$T = \frac{15}{4}mg$ * cso A1 3

(b) N2L B: $T - kmg = km \times \frac{1}{4}g$ M1 A1

$k = 3$ A1 3

(c) The tensions in the two parts of the string are the same B1 1

(d) Distance of A above ground $s_1 = \frac{1}{2} \times \frac{1}{4} g \times 1.2^2 = 0.18g(\approx 1.764)$ M1 A1

Speed on reaching ground $v = \frac{1}{4} g \times 1.2 = 0.3g(\approx 2.94)$ M1 A1

For B under gravity $(0.3g)^2 = 2gs_2 \Rightarrow s_2 = \frac{(0.3)^2}{2} g = (\approx 0.441)$ M1 A1

$S = 2s_1 + s_2 = 3.969 \approx 4.0$ (m) A1 7

[14]

5. $45 = 2u + \frac{1}{2}a2^2 \Rightarrow 45 = 2u + 2a$ M1 A1

$165 = 6u + \frac{1}{2}a6^2 \Rightarrow 165 = 6u + 18a$ M1 A1

eliminating either u or a M1

$u = 20$ and $a = 2.5$ A1 A1

[7]

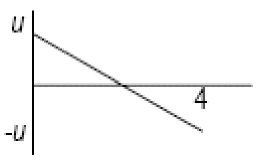
6. $-6\mathbf{i} + \mathbf{j} = \mathbf{u} + 3(2\mathbf{i} - 5\mathbf{j})$ M1 A1

$\Rightarrow \mathbf{u} = -12\mathbf{i} + 16\mathbf{j}$ A1 cso

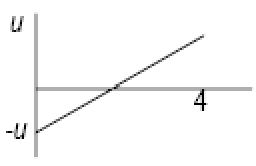
$\Rightarrow u = \sqrt{(-12)^2 + 16^2} = 20$ M1 A1

[5]

7. (a)



<u>or</u>



		shape	B1	
		values	B1	2
	(b)	$19.6 = \frac{1}{2} \times 2 \times u$	M1 A1	
		$u = 19.6$	A1	3

[5]

8.	(a)	*AB:* $50 = 2 \times 22.5 + ½\, a.4$	M1 A1	
		$\Rightarrow a = 2.5 \text{ m s}^{-2}$	A1	3
	(b)	$v^2 = 22.5^2 + 2 \times 2.5 \times 100$	M1 A1ft	
		$\Rightarrow v \approx 31.7(2) \text{ m s}^{-1}$	A1	3

NB note slight changes to scheme: dependency now in (c) and new rule on accuracy of answers.

M1 for valid use of data (e.g. finding speed at B by spurious means and using this to get v at C is M0.
Accept answer as AWRT 31.7

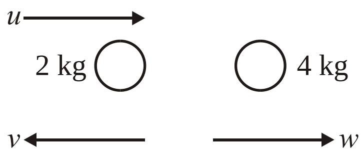
	(c)	$v_B = 22.5 + 2 \times 2.5 = 27.5$ (must be used)	M1	
		$31.72 = 27.5 + 2.5t$ OR $50 = 27.5t + ½ \times 2.5t^2$ OR $50 = ½\,(27.5 + 31.72)t$	M1 A1ft	
		$\Rightarrow t \approx 1.69$ s	A1	4
		OR $31.72 = 22.5 + 2.5T$ OR $100 = 22.5t + ½ \times 2.5T^2$	M1 A1ft	
		$\Rightarrow T \approx 3.69$	↓	
		$\Rightarrow T \approx 3.69 - 2 =$ <u>1.69 s</u>	M1 A1	4
		OR $50 = 31.7t - ½ \times 2.5t^2$	M2 A1ft	
		Solve quadratic to get $t = 1.69$ s	A1	4

In (b) and (c), f.t. A marks are for f.t. on wrong a and / or answer from (b).
(c) M1 + M1 to get to an equation in the required t (normally two stages, but they can do it in one via 3rd alternative above)
Ans is cao. Hence premature approx (-> e.g. 1.68) is A0.
But if they use a 3 sf answer from (b) and then give answer to (c) as 1.7, allow full marks. And accept 2 or 3 s.f. answer or better to (c).

[18]

9.	(a)	Distance after 4 s = $16 \times 4 - \frac{1}{2} \times 9.8 \times 4^2$	M1 A1	

		$= \quad -14.4 \quad \Rightarrow h = (+)\ \underline{14.4\text{ m}}$	A1	3
	(b)	$v = 16 - 9.8 \times 4$	M1 A1	
		$= -23.2 \quad \Rightarrow \quad$ speed $= (+)\ \underline{23.2\text{ ms}^{-1}}$	A1	3
				[6]
10.	(a)	'$v = u + at$': $74 = 2 + a \times 20 \Rightarrow a = \underline{3.6\text{ m s}^{-2}}$	M1 A1	2
	(b)	'$v^2 = u^2 + 2as$': $74^2 = 2^2 + 2 \times 3.6 \times AC$ or '$s = ut + ½at^2$': $AC = 2 \times 20 + ½ \times 3.6 \times 20^2$	M1 A1ft	
		$\Rightarrow AC = 760$ m	A1	
		Hence $BC = 1200 - 760 = \underline{440\text{ m}}$	B1ft	4
				[6]
11.	(a)	$16^2 = 20^2 - 2 \times a \times 24 \Rightarrow a = \underline{3\text{ m s}^{-2}}$	M1 A1	2
	(b)	$v^2 = 20^2 - 2 \times 3 \times 30$	M1 A1ft	
		$v = \sqrt{220}$ or 14.8 m s^{-1}	A1	3
	(c)	$0.3 = m \times 3 \Rightarrow m = 0.1$ kg (*)	M1 A1	2
	(d)	$0.1(w + \sqrt{220}) = 2.4$	M1 A1ft	
		$w = 9.17$	A1 ↓	
		$0 = 9{,}17 - 3 \times t$	M1 A1ft	
		$t \approx \underline{3.06\text{ s}}$	A1	6
				[13]
12.	(a)	$v^2 = 20^2 + 2 \times 4 \times 78 \Rightarrow v = \underline{32\text{ m s}^{-1}}$	M1 A1	2
	(b)	B: $32 = 20 + 4t \Rightarrow t = 3$ s	M1 A1ft ↓	
		A: Distance $= 30 \times t = \underline{90\text{ m}}$	M1 A1	4
	(c)	$30T = 20T + ½ .4.T^2$	M1 ↓	
		$2T^2 - 10T = 0$	M1 A1 ↓	
		$\Rightarrow t = (0\text{ or})\ \underline{5\text{ s}}$	M1 A1	5
				[11]

13.	(a)	'$v = u + at$': $9.5 = 5 + 1.5a \Rightarrow a = 3$	M1 A1 ↓	
		Hence $v^2 = 5^2 + 2 \times 3 \times 24$	M1	
		$= 169 \Rightarrow v = \underline{13 \text{ m s}^{-1}}$ (*)	A1	4
	(b)	'$I = mv - mu$' : $-30 = 2(v - 13) \Rightarrow v = (-)\ 2 \text{ m s}^{-1}$	M1 A1	
		In direction of CA (o.e.)	A1	3
				[7]
14.	(a)			
		CLM: $2u = -2v + 4w$	M1 A1 ↓	
		Using $w = 3v$ ($\Rightarrow 2u = -2v + 12v$) and solve	M1	
		$\Rightarrow v = \frac{1}{5}u$ (*)	A1 cso	4
	(b)	$10 = 2a \Rightarrow a = 5 \text{ m s}^{-2}$	B1	
		$0 = \frac{1}{25}u^2 - 2 \times 5 \times 1.6$	M1 A1f.t. ↓	
		$\rightarrow u = \underline{20 \text{ m s}^{-1}}$	M1 A1	5
				[9]
15.	(a)	$0^2 = u^2 - 2 \times 9.8 \times 40$	M1 A1	
		$\Rightarrow \underline{u = 28 \text{ ms}^{-1}}$	A1	3
	(b)	$-28 = 28 - 9.8 \times t$	M1 A1	
		$\Rightarrow \underline{t = 5.7 \text{ or } 5.71\ s}$	A1	3
				[6]
16.	(a)	"$v^2 = u^2 + 2as$" : $v^2 = 4^2 + 2 \times g \times 5$	M1 A1	
		$v \approx 10.7 \text{ m s}^{-1}$ (accept 11 m s^{-1})	A1	3
	(b)	"$v = u + at$" : $-10.7 = 4 - gt$	M1 A1 ft	
		$t = \dfrac{14.7}{g} = 1.5 \text{ s}$	A1	3
	(c)	Air resistance; 'spin'; height of diver; hit board again <u>or</u> horizontal component of velocity (any two)	B1 B1	2

[8]

17. (a)	$v^2 = u^2 + 2as$:	$0 = u^2 - 2 \times 9.8 \times 25.6$	M1 A1	
		$u^2 = 501.76 \Rightarrow u = 22.4$ **(*)**	A1cso	3
(b)	$-1.5 = 22.4T - 4.9T^2$		M1 A1	
	$4.9T^2 - 22.4T - 1.5 = 0$			
	$T = \dfrac{22.4 \pm \sqrt{22.4^2 + 4 \times 1. \times 4.9)}}{9.8}$		M1	
	$= 4.64$ s		A1	4
(c)	Speed at ground $v = 22.4 - 9.8 \times 4.64$		M1	
	$v = -23.07$		A1	
	(or $v^2 = 22.4^2 + 2 \times 9.8 \times 1.5$, $v = 23.05$)			
	$v^2 = u^2 + 2as$:	$0 = 23.07^2 + 2 \times a \times 0.025$	M1 A1 ft	
		$(\rightarrow a = -10644.5)$		
	$F - 0.6g = 0.6a$		M1	
	$F = 6390$ N (3 sf)		A1	6
(d)	Air resistance; variable F;		B1	1

[14]

18. (a)	$34^2 = 16^2 + 2 . a . 150$		M1 A1	
		$\Rightarrow a = 3$ m s^{-2}	A1	3
(b)	hence $t = \dfrac{34 - 16}{a} = 6$ s		M1 A1	2
(c)	$v^2 = 16^2 + 2.3.75$			
	$\Rightarrow v \approx 26.6$ m s^{-1}		M1 A1	2

[7]

19. (a)	"$v^2 = u^2 + 2as$":	$V^2 = 2 . 9.8 . 1.6$	M1	
		$\Rightarrow$ V = 5.6 m s^{-1}	A1	2
(b)	$78 . 5.6 = 84 . v$		M1 A1	
	$\Rightarrow v = 5.2$ m s^{-1}		A1	3

(c)	$84 \,.\, 5.2 = F \,.\, 0.06 - 84g \,.\, 0.06$	M1 A1 A1	
	$\Rightarrow F = 8103.2$ N	A1	4
	"$F = ma$": $8103.2 - 84g = 84a \Rightarrow a = 86.67$	M1 A1	
(d)	"$v^2 = u^2 + 2as$": $5.2^2 = 2 \,.\, 86.67 \,.\, s$	M1	
	$\Rightarrow s \approx 0.156$ m, or 0.16 m to 2 s.f.	A1	2

[11]

1. This question was generally well done and often a useful source of marks for weaker candidates. Virtually all used a valid method to find the greatest height although not all added on the '49' to take account of the starting level. Those who did often failed to give their answer to an appropriate degree of precision (2 or 3 significant figures having used $g = 9.8$). Part (b), which involved finding the velocity at ground level, was also largely successfully completed although there was occasional confusion about which figure for height to use. To find the time of flight in part (c), many candidates split the motion into up/down stages and were largely successful. Those who tried to use the whole motion sometimes made sign errors.

2. In parts (a) and (b), most were able to make a reasonable attempt at two equations of motion, but there were errors in signs and solutions. This was not helped by the fact that T was asked for first rather than a and some candidates lost marks due to trying to solve for T first rather than the easier route of solving for a. A few attempted the whole system equation and these solutions were in general less successful than those who used two separate equations to start with. In the last part, too many candidates were unable to visualise the situation clearly and then deal with it in a methodical fashion. If they failed to find both the velocity of A on impact with the ground and the distance that it had travelled they were unable to progress any further. Only the more able students managed correct solutions. Of those that managed to progress in part (c), there were sign errors which caused problems. Many chose to split the motion of B into two parts and these were usually quite successful provided that the extra distance travelled by B in the upward direction was taken into account.

3. Part (a) had a very high success rate and all three marks were regularly scored but the second part was found to be more challenging. Most were able to resolve perpendicular to the plane to find the reaction and use it to find the limiting friction. However, all too often there were omissions from the equation of motion parallel to the plane, either the mass x acceleration term and/or the weight component or else g was missing. Part (c) was a good discriminator and candidates needed to realise that this was a new system and that there was no acceleration. Those who failed to appreciate this and used their friction force from part (b) scored no marks. The majority of successful candidates resolved parallel and perpendicular to the plane (although a sizeable minority resolved vertically and horizontally) but even then a correct final answer was rarely seen due to premature approximation or else it was given to too many figures.

4. Part (a) was reasonably well done by the majority of students, with good use of the printed answer to correct sign errors etc. but there was less success in the second part, with omission of m and/or g from some terms. The mark in part (c) was very rarely scored and candidates should be aware that if they give a 'list' of answers they will not be awarded the mark, even if the correct answer appears in their list. The final part was a good discriminator and led to this question being the worst answered question on the paper. Consideration of two stages to the motion was required, with two distinct accelerations. Many completely omitted the motion under gravity and found the distance moved by A and either gave that as their answer or else just doubled it.

5. This was a more difficult question 1 than usual, in that neither u nor a could be found directly from the given information and it was necessary to set up a pair of simultaneous equations. Many were able to write down an equation for the motion from P to Q but then struggled to find another one. By far the most common error was to say that the average velocity over an interval was equal to the actual velocity at one end of it. Those candidates who produced two correct equations invariably produced the correct answers. A few candidates found the acceleration but then forgot to find the value of u.

6. Most candidates realised that they needed to apply $\mathbf{v} = \mathbf{u} + \mathbf{a}\,t$ and many arrived at $12\mathbf{i} - 16\mathbf{j}$ but then failed to go on and find the speed, losing the final two marks. This showed a lack of understanding of the relationship between speed and velocity. A small minority found magnitudes at the start and then tried to use $v = u + at$, gaining no marks. Some candidates lost the third mark because of errors in the manipulation of negative numbers.

7. Only a relatively small number of candidates had a correct graph in part (a). There was a whole variety of incorrect attempts seen. Many of the graphs were curved and in some cases the path that the ball would take in the air was drawn. Of those who had a straight line many were reluctant to go below the t-axis into negative velocities and drew a speed-time graph instead. Part (b) was more successfully answered but a common error was to use a wrong time value. Students generally used constant acceleration formulae rather than the area under their graph.

8. A good number of fully correct solutions were seen here. The formulae for constant acceleration were generally well known and accurately used. Mistakes sometimes arose from confusing B and C in part (b). In part (c), quite a few chose to use a method involving a quadratic equation in t, though they were often successful and accurate in doing this, even though simpler solutions were available via other approaches. The most common error was to use a prematurely rounded answer for the speed at C, which then led to an inaccurate answer in part (c) (1.68 instead of 1.69).

9. For candidates who realised the most efficient method (using a single constant acceleration equation in both parts), this was a relatively easy first question, though several failed to take account of the appropriate signs in the equations. However, probably more than 50% of the candidates chose to make the question considerably more complex by dividing the motion up into two or three parts, considering the motion to the highest point, and then down to the ground (or in even more stages). Some succeeded in getting to the correct answers, but often there were accuracy errors en route. Many also made unjustified assumptions about the motion (e.g. that the highest point was reached after precisely 2 seconds or that initial speed was zero). Some candidates fared slightly better in part (b), but again were evidently sometimes confused about which distance was which, and whether the ball had a non-zero or zero initial velocity.

10. The question was generally well answered, though by no means fully correctly by all. Some launched straight into using their standard equations without quite understanding the actual situation: e.g. a number found only the distance AC, failing to deduce the distance BC; and some appeared to assume that the point C was beyond the end B of the runway. However, most could make good progress with most of this question. It was also slightly disappointing to see a number of candidates unable to handle accurately the units involved, e.g. taking 1.2 km as 1.2 m.

11. Most could make good attempts at the first three parts of the question, though a misreading of the information (confusing 'AC' and 'BC' was not uncommon). In part (d) the most common mistake was to confuse signs again (similar to qu.1) in writing down the impulse-momentum equation, but most could then go on to use their result in an appropriate way to get a value for the time.

12. This was a good source of marks for many with many fully correct solutions seen. The first two parts were very well done. In part (c), some equated speeds rather than distances; also some failed to realise that one needed to use a general expression (in an unknown T) for A as well as B. A number of candidates used a 'trial and error' approach, somehow plucking a value of '5' out of the air and verifying that it 'worked'. Such an approach is not to be encouraged as it can scarcely apply to more complex problems where there might be more than one solution to the relevant equations and one may not know if the one discovered is the appropriate one.

13. Part (a) was well done by the great majority of candidates, though some reached the required answer by finding the distances involved in the separate stages of the motion, thus making the problem longer than necessary. In part (b) most realised that they had to write down an impulse-momentum equation; however, many failed to deal correctly with the signs in the equation and realising the relative directions of the impulse and the initial velocity. As a result, answers of $v = 28 \text{ m s}^{-1}$ were quite frequent. For those who successfully found the final velocity correctly, nearly all could identify the direction as well.

14. Most could form a correct conservation of momentum equation and could make an attempt to interpret the data about the speeds after the collision by putting the two speeds in terms of a single unknown. Several however found their unknown to be $0.6u$ without apparently realising that they had found the speed of Q rather than P. It was pleasing to see most candidates keeping the letter u in their working all the time. In part (b) several correct answers were seen; most correctly obtained the deceleration, but a number failed to use the correct sign for their acceleration term in their equation to find u (simply riding roughshod over the fact the u^2 was coming out to be negative).

15. Although most candidates made some attempt at this question, and many obtained the 'correct' numerical answer in part (a), the majority failed to provide a fully convincing solution to the problem. Many used the equation '$v = u + 2as$' somewhat unthinkingly by equating their 'u' (which in the absence of any indication to the contrary was assumed to be the initial speed) to 0 (which is then not the solution to the problem set). In part (b) a number only found the time to the highest point and therefore again failed to understand the mechanics of the situation; some also approximated their answers prematurely, e.g. by finding the time to the highest point to 3 s.f., and then simply doubling this rounded answer. On the whole, however, part (b) was generally done better than part (a).

16. The equations for constant acceleration were well known and generally applied appropriately. Mistakes did however tend to arise with candidates failing to allow for the different directions of motion at different stages so that the sign used with the velocity had to be carefully taken into consideration. A significant number of candidates also insisted on making the question quite a lot longer than necessary by splitting the motion up into separate parts (e.g. to the highest point and then down) and doubling (or more) the number of calculations required. Some candidates also lost a mark by failing to round their answers ‘appropriately’, i.e. by giving their answer to 2 or 3 significant figures where they had used g as 9.8. In part (c) an appeal to air resistance was frequently correctly given, though quite a number also incorrectly stated that the mass/weight of the diver had been ignored in the model.

17. Part (a) was generally well done, though weaker candidates tended to make mistakes with the signs and then ended up having to take the square root of a negative number. In part (b), there were often sign errors and/or failure to appreciate the final vertical displacement from the initial position (some took this to be the total distance travelled, both up and down). Others split the motion up into two parts, finding the time to the highest point and then the time down. Some though simply found the time for one part of the motion only. Part (c) proved to be much more demanding. Several used the value 22.4 still for the initial speed in this part of the motion. A failure to convert 2.5 cm into metres was not uncommon; and almost all failed to take any account of the weight in writing down the equation of motion to find the resistive force.

18. No Report available for this question.

19. No Report available for this question.