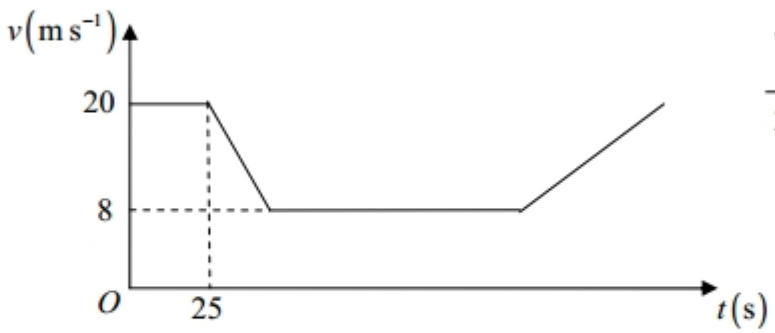
A level Applied Paper 3B Mechanics Practice Paper M12 MARK SCHEME

Question 1

Question Number	Scheme	Marks
	(a) 	B1 B1 B1 **(3)**
	(b) $v = u + at \Rightarrow 8 = 20 - 0.4t$ $t = 30$ (s)	M1 A1 **(2)**
	(c) $1960 = (25 \times 20) + (30 \times 8) + (\tfrac{1}{2} \times 30 \times 12) + (60 \times 8) + 8 \times t + \tfrac{1}{2} \times t \times 12$	M1A3 **ft** (2 ,1, 0)
	$1960 = 500 + 240 + 180 + 480 + 14t$	DM1 A1
	$T = 115 + 40$ $= 155$	DM1 A1
	N.B. SEE ALTERNATIVES	**(8)** **[13]**

(a)
First B1 for 1st section of graph
Second B1 for 2nd section
Third B1 for the figures 20, 8 and 25

(b)
M1 for a complete method to produce an equation in t only; allow $(20 - 8)/0.4$
A1 for 30 N.B.
Give A0 for $t = -30$, even if changed to 30, but then allow use of 30 in part (c), where full marks could then be scored.

(c)

First M1 (generous) for clear attempt to find whole area under *their* graph (must include at least one "1/2"), in terms of *a single unknown time (t say),* and equate it to 1960.
First A3, ft on their (b), for a correct equation.
Deduct 1 mark for each numerical error, or omission, in each of the 4 *sections of the area* corresponding to each stage of the motion. (they may 'slice' it, horizontally into 3 sections, or a combination of the two)
Second DM1, dependent on first M1, for simplifying to produce an equation with all their *t* terms collected.
Fourth A1 for a correct equation for *t* or *T*
Third DM1, dependent on second M1. for solving for *T*
Fifth A1 155

Please note that any incorrect answer to (b) will lead to an answer of 155 in (c) and can score max 6/8;
Solutions with the correct answer of 155 will need to be checked carefully.
Solutions to (c) **N.B.** $t = T - 115$

A. $1960 = (25 \times 20) + (30 \times 8) + (\frac{1}{2} \times 30 \times 12) + (60 \times 8) + 8 \times t + \frac{1}{2} \times t \times 12$ M1 A3 **ft**
$1960 = 500 + 240 + 180 + 480 + 14t$ M1 A1
$T = 115 + 40$ M1
$= 155$ A1

B. $1960 = (25 \times 20) + \frac{1}{2} \times 30 \times (20 + 8) + (60 \times 8) + \frac{1}{2} \times t \times (20 + 8)$ M1 A3 **ft**
$1960 = 500 + 420 + 480 + 14t$ M1 A1
$T = 115 + 40$ M1
$= 155$ A1

C. $1960 = 8T + \frac{1}{2} \times 12 \times (55 + 25) + \frac{1}{2} \times 12 \times (T - 115)$ M1 A3 **ft**
$1960 = 8T + 480 + 6T - 690$
$1960 = 14T - 210$ M1 A1
$155 = T$ M1 A1

D. $1960 = 20T - \frac{1}{2} \times 12 \times (60 + T - 25)$ M1 A3 **ft**
$1960 = 20T - 6T - 210$
$1960 = 14T - 210$ M1 A1
$155 = T$ M1 A1

E. $1960 = (55 \times 20) - \frac{1}{2} \times 30 \times 12 + (60 \times 8) + \frac{1}{2} \times t \times (20 + 8)$ M1 A3 **ft**
$1960 = 1100 - 180 + 480 + 14t$ M1 A1
$T = 115 + 40$ M1
$= 155$ A1

F. $1960 = (8 \times 115) + \frac{1}{2} \times 12 \times (55 + 25) + \frac{1}{2} \times 28 \times (T - 115)$ M1 A3 **ft**
$1960 = 920 + 480 + 14T - 1610$
$1960 = 14T - 210$ M1 A1
$155 = T$ M1 A1

Question 2

Question Number	Scheme	Marks
	(a) $v^2 = u^2 + 2as \Rightarrow 28^2 = u^2 + 2\times 9.8\times 17.5$	M1 A1
	Leading to $u = 21$ ✱ cso	A1 (3)
	(b) $s = ut + \frac{1}{2}at^2 \Rightarrow 19 = 21t - 4.9t^2$	M1 A1
	$4.9t^2 - 21t + 19 = 0$	
	$t = \frac{21 \pm \sqrt{21^2 - 4\text{x}4.9.\text{x}19}}{9.8}$	
	$t = 2.99$ or 3.0	DM1 A1 A1
	$t = 1.30$ or 1.3	(5)
	(c) N2L $4g - 5000 = 4a$	M1 A1
	$(a = -1240.2)$	
	$v^2 = u^2 + 2as \Rightarrow 0^2 = 28^2 - 2\times 1240.2\times s$	
	Leading to $s = 0.316$ (m) or 0.32	M1 A1 (4)
		[12]
	OR	
	$\frac{1}{2}$ x 4 x $28^2 + 4gs = 5000s$	M1 A1
	Work-Energy: $s = 0.316$ or 0.32	M1 A1

(a)

First M1 for a complete method for finding u e.g.
$28^2 = u^2 + 2g\times 17.5$
or $282 = u^2 + 2(-g)\times(-17.5)$
or $282 = 2gs \Rightarrow s = 40$ then $0^2 = u^2 + 2(-g)\times(22.5)$
condone sign errors
First A1 for a correct equation(s) with $g = 9.8$
Second A1 for "$u = 21$" PRINTED ANSWER
N.B. Allow a verification method, but they must state, as a conclusion, that "$u = 21$" , to score the final A1.

(b)

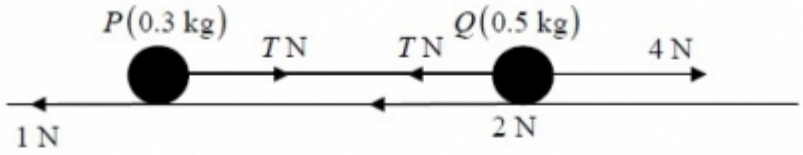
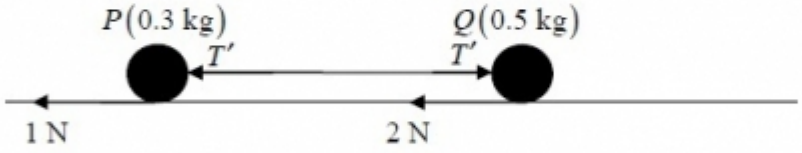
First M1 for a complete method for finding at least one t value i.e. for producing an equation in t only. (condone sign errors but not missing terms)
First A1 for a correct quadratic equation in t only or TWO correct linear equations in t only.
Second DM1, dependent on first M1, for attempt to solve the quadratic or one of the linear equations.
Second A1 for 3.0 or 3 or 2.99
Third A1 for 1.3 or 1.30

(c)

First M1 for resolving vertically with usual rules.

First A1 for a correct equation
Second M1 for use of $v^2 = u^2 + 2as$, with $v = 0$, $u = 28$ or $u = 0$ and $v = 28$ and their a, (or any other complete method which produces an equation in s,which could be negative)
M0 if they haven't *calculated* a value of a.
Second A1 for 0.32 or 0.316. (must be positive since it's a distance)

Question 3

Question Number	Scheme	Marks
		
	(a) For system N2L $4-3=0.8a$ $a=1.25\ (\text{m s}^{-2})$, 1.3	M1 A1 A1 (3)
	(b) $v=u+at \Rightarrow v=0+1.25\times 6=7.5\ (\text{m s}^{-1})$	M1 A1 (2)
	(c) For P N2L $T-1=0.3\times 1.25$ ft their a $T=1.375$ (N) 1.38, 1.4	M1 A1ft A1 (3)
	OR For Q N2L 4 - $2-T=0.5$ x 1.25	
		
	(d) For system N2L $-3=0.8a \Rightarrow a=-3.75$ $v^2=u^2+2as \Rightarrow 0^2=7.5^2-2\times 3.75s$ $s=7.5$ (m)	M1 A1 M1 A1 (4)
	(e) For P N2L $T'+1=0.3\times 3.75$ $T'=0.125$ (N), 0.13	M1 A1 A1 (3) [15]
	Alternative for (e) For Q N2L $2-T'=0.5\times 3.75$ $T'=0.125$ (N), 0.13	M1 A1 A1 (3)

(a)*(In parts (a), (c), (d) and (e) use the value of the mass being used to guide you as to which part of the system is being considered, and mark equation(s) accordingly)*
M1 for resolving horizontally to produce an equation in *a* ONLY.
First A1 for a correct equation
Second A1 for 1.25

(b)

M1 for a complete method to find the speed
A1 cao 7.5

(c)

M1 for resolving horizontally, for either P or Q, to produce an equation in T only.
First A1ft for a correct equation,ft on their a
Second A1 cao for 1.38 (N) or 1.375 (N)

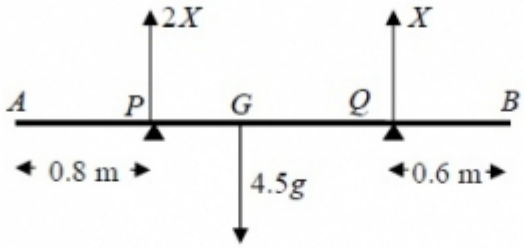
(d)

First M1 for resolving horizontally to produce an equation in a ONLY.
First A1cao for −3.75 (or 3.75)
Second M1 for use of $v^2 = u^2 + 2as$, with $v = 0$, u= their (b) and their a, (or any other complete method which produces an equation in s only)
M0 if they haven't *calculated* a value of a.
Second A1 for 7.5 m

(e)

M1 for resolving horizontally, for either P or Q, to produce an equation in T only.
M0 if they haven't *calculated* a value of a
First A1cao for a correct equation
Second A1 cao for 0.125 or 0.13 (N) (must be positive)

Question 4

Question Number	Scheme	Marks
		
(a)	$\uparrow \quad 2X + X = 4.5g$	M1 A1
	Leading to $X = \frac{3g}{2}$ or 14.7 or 15 (N)	A1 **(3)**
(b)	$M(A) \quad 4.5g \times AG = (2X) \times 0.8 + X \times 2.4$	M1 A2 **ft** (1,0)
	$AG = \frac{4}{3}$ (m), 1.3, 1.33,...	A1 **(4)**
		[7]

(a)

First M1 for a complete method for finding R_P, either by resolving vertically, or taking moments twice, with usual criteria (allow M1 even if R_P =2R_P not substituted)

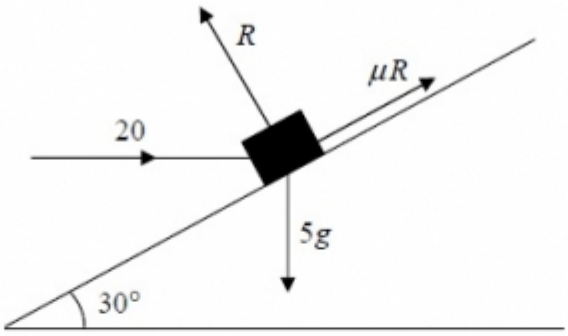
First A1 for a correct equation in either R_P or R_P ONLY.
Second A1 for 1.5g or 14.7 or 15 (A0 for a negative answer)

(b)

First M1 for taking moments about any point, with usual criteria.
A2 ft for a correct equation (A1A0 one error, A0A0 for two or more errors, ignoring consistent omission of g's) in terms of *X* and their *x* (which may not be *AG* at this stage)
Third A1 for *AG* = 4/3, 1.3, 1.33,.....(any number of decimal places, since g cancels) need '*AG* =' or *x* marked on diagram.

N.B. if R_P = 2R_P throughout, mark as a misread as follows:
(a) M1A1A0 (resolution method) (b) M1A0A1A1, assuming all work follows through correctly..

Question 5

Question Number	Scheme	Marks
		
	(a) ⊥ plane $R = 20\cos 60° + 5g\cos 30°$ $= 52.4\ (\text{N})$ or 52	M1 A2(1,0) A1 **(4)**
	(b) $F_r = \mu R$ P plane $F + 20\cos 30° = 5g\cos 60°$ Leading to $\mu = 0.137$ or 0.14	B1 M1 A2(1, 0) A1 **(5)** **[9]**

(a)

First M1 for resolving perpendicular to plane with usual criteria
First A2 for a correct equation (A1A0 one error, A0A0 for two or more errors)
Second A1 for either 52 or 52.4
N.B. In part (a), the M1 is for a complete method, so they must have sufficient equations to be able to solve for *R*. The A2 marks are then for *all* the equations.

(b)

B1 for use of $F=\mu R$ (could just be on diagram)
First M1 (allow if *F* is used rather than μR) for resolving parallel to the plane with usual criteria
First A2 for a correct equation (A1A0 one error, A0A0 for two or more errors)
Second A1 for either 0.14 or 0.137
N.B. If they resolve vertically AND horizontally, there are max 6 marks available (M1A2, M1A2) for the TWO equations, but if they only have one equation, there are no marks available for that equation.
The marks for the horizontal resolution should be entered first on ePen.

Question 6

Question Number	Scheme	Marks	Notes
(a)	$M(A), F.4\sin 40^\circ = 5g.2\cos 25^\circ$	M1	A complete method to find F, e.g. take moments about A. Condone sin/cos confusion. Requires correct ratio of lengths.
		A1	Correct terms with at most one slip
		A1	All correct
	$F = 35$	A1	35 or 34.5 (>3sf not acceptable due to use of 9.8, but only penalise once in a question)
		(4)	
(b)	$F\cos 75^\circ \pm Y = 5g$	M1	Resolve vertically. Need all three terms but condone sign errors. Must be attempting to work with their 75° or 15°.
		A1	Correct equation (their F)
	$Y = 40$;	A1	40 or 40.1
	UP	A1	Apply ISW if the candidate goes on to find R. cso (the Q does specifically ask for the direction, so this must be clearly stated)
		(4)	
		8	
(b)	OR1: $4m\cos 25 \times Y = 5g \times 2m\cos 25 + F\cos 15 \times 4m\sin 25$ etc.	M1 A1	Taking moments about the point vertically below B and on the same horizontal level as A. (Their F)
	OR2: $R\cos\alpha = F\cos 40 + 5g\cos 65$ $R\sin\alpha + F\sin 40 = 5g\cos 25$		Resolve parallel & perpendicular to the rod
	R=52.1, α=25.3°		Solve for R, α
	$Y = R\sin(25+\alpha)$ Etc.	M1A1	Need a complete strategy to find Y for M1.

Question 7

Question Number	Scheme	Marks	Notes
(a)	$\mathbf{a} = \frac{d\mathbf{v}}{dt} = 6\mathbf{i} + (4-2t)\mathbf{j}$	M1	Differentiate **v** to obtain **a**.
		A1	Accept column vector or **i** and **j** components dealt with separately.
	When $t = 1$, $\mathbf{a} = 6\mathbf{i} + 2\mathbf{j}$	DM1	Substitute t = 1 into their **a**. Dependent on 1st M1
	$\lvert\mathbf{a}\rvert = \sqrt{6^2 + 2^2} = \sqrt{40} = 6.32$ (m s^{-2})	DM1	Use of Pythagoras to find the magnitude of their **a**. Allow with their t. Dependent on 1st M1
		A1	Accept awrt 6.32, 6.3 or exact equivalents.
		(5)	
(b)	$\mathbf{r} = \int (3t^2 - 1)\mathbf{i} + (4t - t^2)\mathbf{j}\, dt$	M1	Integrate **v** to obtain **r**
	$= (t^3 - t + C)\mathbf{i} + (2t^2 - \frac{1}{3}t^3 + D)\mathbf{j}$	A1	Condone C, D missing
	$t = 0, \mathbf{r} = \mathbf{i} \Rightarrow C = 1, D = 0$	DM1	Use t = 0, **r** = **i** to find C & D
	When $t = 3$, $\mathbf{r} = 25\mathbf{i} + 9\mathbf{j}$ (m)	DM1	Substitute t = 3 with their C & D to find **r**. Dependent on both previous Ms.
		A1	cao. Must be a vector.
		(5)	
		10	

Question 8

Question Number	Scheme	Marks
	(a) $\arctan\frac{7.5}{12}=32°$	M1 A1
	Bearing is 302 (allow more accuracy)	A1 (3)
	(b) $\mathbf{s}=40\mathbf{i}-6\mathbf{j}+t(-12\mathbf{i}+7.5\mathbf{j})$	M1 A1 (2)
	(c) $t=3$, $\mathbf{s}=4\mathbf{i}+16.5\mathbf{j}$	M1
	$\mathbf{s}-\mathbf{b}=-3\mathbf{i}+4\mathbf{j}$	M1
	$SB=\sqrt{\left((-3)^2+4^2\right)}=5\ (\text{km})$	DM1 A1 (4)
	(d) Equating **i** components	
	$40-12t=7$ **or** $-33+12t=0$	M1
	$t=2\frac{3}{4}$	A1
	When $t=2\frac{3}{4}$, $\mathbf{s}=(7\mathbf{i})+14\frac{5}{8}\mathbf{j}$	M1
	$SB=2\frac{1}{8}$ (km) 2.125, 2.13	A1 (4)
		[13]
	OR When $t=2\frac{3}{4}$, $7.5t-18.5=2.125, 2.13$	M1 A1

(a)

First M1 for $\arctan\left(\frac{\pm7.5}{\pm12}\right)$ either way up
First A1 for a correct value from their expression, usually 32° or 58°
Second A1 for 302 (allow more accurate answers)

(b)

M1 for a clear attempt at (40**i** − 6**j**)+*t*(−12**i** + 7.5**j**)
A1 for any correct expression

(c)

First M1 is really B1 for 4**i** + 16.5**j** (seen or implied but can be in unsimplified form)
Second M1 is for a subtraction, **s** − **b** or **b** − **s**.
Third DM1, dependent on second M1, for finding magnitude of their **s** − **b** or **b** − **s**
A1 for 5

(d)

First M1 for equating **i-**component of their answer in part (b) to 7 or
the **i-**component of their **s** − **b** or **b** − **s** to zero
First A1 for 2.75 cao
Second M1 (independent) for attempt to find **j-**component of their s at their
t = 2.75
Second A1 2.125 or 2.13 cao

Question 9

Question Number	Scheme	Marks	
(a)	$0^2 = u_V^2 - 2 \times 9.8 \times 10$	M1	Complete method using *suvat* to form an equation in u_V.
		A1	Correct equation e.g. $0 = u^2 - 20g$
	$u_V = 14$ *	A1	*Answer given* requires equation and working, including 196, seen.
		(3)	
OR	conservation of energy:	M1	Initial KE = gain in GPE + final KE
	$\frac{1}{2}m(u_h^2 + u_v^2) = mg \times 10 + \frac{1}{2}mu_h^2, \frac{1}{2}u_v^2 = 98$	A1	Correct equation
	$u_V = 14$ *	A1	*Answer given*
		(3)	
(b)		M1	Use the vertical distance travelled to find the total time taken.
	$(\uparrow),\ -52.5 = 14t - \frac{1}{2}gt^2$	A1	At most one error
		A1	Correct equation
	$49t^2 - 140t - 525 = 0$	DM1	Solve for t. Dependent on the preceding M mark
	$(t-5)(49t+105) = 0 \quad t = 5$	A1	only
	$(\rightarrow),\ 50 = 5u_H$	M1	Use their time of flight to form an equation in u_H
	$u_H = 10$	A1	only
	$u = \sqrt{10^2 + 14^2}$	M1	Use of Pythagoras with two non-zero components, or solution of a pair of simultaneous equations in u and α.
	$= \sqrt{296}\ ;\ 17.2\ \text{m s}^{-1}$	A1	17.2 or 17 (method involves use of g = 9.8 so an exact surd answer is not acceptable)
		(9)	
			See next page for an alternative route to u, and (c).
OR			First 3 marks for the quadratic as above.
	$50 = u\cos\alpha t$ or $50 = u_H t$	M1	Used in their quadratic
	$49\left(\frac{50}{u_H}\right)^2 - 140\left(\frac{50}{u_H}\right) - 525 = 0$	A1	Correct quadratic in u_H
	$525(u_H)^2 + 140(u_H) - 122500 = 0$		
	Solve for u_H	DM1	Dependent on the M mark for setting up the initial quadratic equation in t.
	$u_H = 10$	A1	only
	etc.		Complete as above.
(c)	$\tan OBA = \frac{52.5}{50} = 1.05$	B1	Correct direction o.e. (accept reciprocal)
	$v_V = 1.05 \times 10 = 10.5$	M1	Use trig. with their u_H and correct interpretation of direction to find the vertical component of speed. Working with distances is M0. (condone $10 \div 1.05$)
	$(\uparrow),\ -10.5 = 14 - gt$	DM1	Use suvat to form an equation in t. Dependent on the preceding M.
		A1	Correct equation for their u_H For incorrect direction give A0 here.
	$t = 2.5$	A1	only
		(5)	
		17	