Questions

Q1.

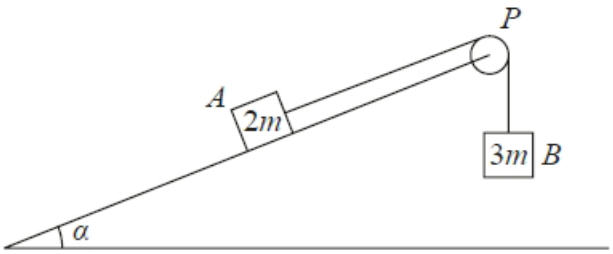


Figure 1

Two blocks, *A* and *B*, of masses 2*m* and 3*m* respectively, are attached to the ends of a light string.

Initially *A* is held at rest on a fixed rough plane.

The plane is inclined at angle α to the horizontal ground, where $\tan\alpha = \frac{5}{12}$

The string passes over a small smooth pulley, *P*, fixed at the top of the plane.

The part of the string from *A* to *P* is parallel to a line of greatest slope of the plane.
Block *B* hangs freely below *P*, as shown in Figure 1.

The coefficient of friction between *A* and the plane is $\frac{2}{3}$

The blocks are released from rest with the string taut and *A* moves up the plane.

The tension in the string immediately after the blocks are released is *T*.

The blocks are modelled as particles and the string is modelled as being inextensible.

(a) Show that $T = \frac{12mg}{5}$

(8)

After *B* reaches the ground, *A* continues to move up the plane until it comes to rest before reaching *P*.

(b) Determine whether *A* will remain at rest, carefully justifying your answer.

(2)

(c) Suggest two refinements to the model that would make it more realistic.

(2)

(Total for question = 12 marks)

Q2.

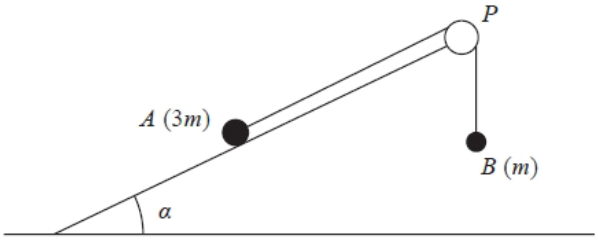


Figure 1

A small stone *A* of mass 3*m* is attached to one end of a string.

A small stone *B* of mass *m* is attached to the other end of the string.

Initially *A* is held at rest on a fixed rough plane.

The plane is inclined to the horizontal at an angle α, where $\tan \alpha = \frac{3}{4}$

The string passes over a pulley *P* that is fixed at the top of the plane.

The part of the string from *A* to *P* is parallel to a line of greatest slope of the plane.

Stone *B* hangs freely below *P*, as shown in Figure 1.

The coefficient of friction between *A* and the plane is $\frac{1}{6}$

Stone *A* is released from rest and begins to move down the plane.

The stones are modelled as particles.

The pulley is modelled as being small and smooth.

The string is modelled as being light and inextensible.

Using the model for the motion of the system before *B* reaches the pulley,

(a) write down an equation of motion for *A*

(2)

(b) show that the acceleration of *A* is $\frac{1}{10}g$

(7)

(c) sketch a velocity-time graph for the motion of *B*, from the instant when *A* is released from rest to the instant just before *B* reaches the pulley, explaining your answer.

(2)

In reality, the string is not light.

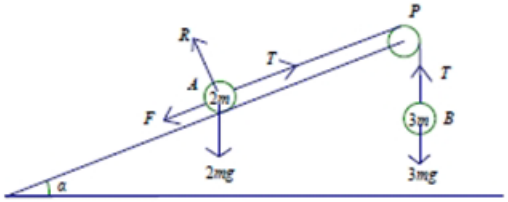
(d) State how this would affect the working in part (b).

(1)

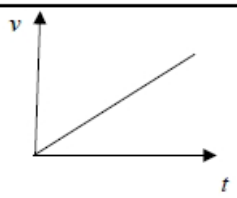
(Total for question = 12 marks)

Mark Scheme

Q1.

Part	Working or answer an examiner might expect to see	Mark	Notes
(a)			
	$R = 2mg\cos\alpha = \frac{24mg}{13}$	B1	This mark is given for using the model to state the normal reaction between A and the plane
	$F_{max} = \frac{2}{3}R = \frac{16mg}{13}$	B1	This mark is given for the use of $F = \mu R$
	Equation of motion for A is $T - F_{max} - 2mg\sin\alpha = 2ma$	M1	This mark is given for a method form an equation of motion for A
		A1	This mark is given for a correct equation of motion for A
	Equation of motion for B is $3mg - T = 3ma$	M1	This mark is given for a method to form an equation of motion for B
		A1	This mark is given for a correct equation of motion for B
	$3mg - \frac{16mg}{13} - \frac{10mg}{13} = 5ma$	M1	This mark is given for a method using the equations of motion for A and B to solve for T
	$T = 3mg - \frac{3mg}{5} = \frac{12mg}{5}$	A1	This mark is given for a full method and correct working to show the answer given
(b)	$F_{max} = \frac{16mg}{13} > \frac{10mg}{13}$ $\frac{10mg}{13}$ is the component of the weight parallel to the slope	M1	This mark is given for a comparison of F_{max} with the component of weight
	Thus A will not move	A1	This mark is given for a fully justified and correct conclusion
(c)	Have the model consider air resistance	B1	This mark is given for one correct refinement stated
	Have the model use an extensible string	B1	This mark is given for one correct refinement stated

Q2.

Question	Scheme	Marks	AOs
	Mark parts (a) and (b) together		
(a)	Equation of motion for A	M1	3.3
	$3mg\sin\alpha - F - T = 3ma$	A1	1.1b
		(2)	
(b)	Resolve perpendicular to the plane	M1	3.4
	$R = 3mg\cos\alpha$	A1	1.1b
	$F = \frac{1}{6}R$	B1	1.2
	Equation of motion for B **OR** for whole system	M1	3.3
	$T - mg = ma$ **OR** $3mg\sin\alpha - F - mg = 3ma + ma$	A1	1.1b
	Complete method to solve for a	DM1	3.1b
	$a = \frac{1}{10}g$ *	A1*	2.2a
		(7)	
(c)		B1	1.1b
	e.g. acceleration (of B) is constant; dependent on first B1	DB1	2.4
		(2)	
(d)	e.g. the tensions in the two equations of motion would be different. Tension on A would be different to tension on B	B1	3.5a
		(1)	
			(12 marks)

Notes:	N.B. If m's are consistently missing treat as a MR, so max (a) M1A0 (b) M1A0B0M1A1M1A1 (c) B1B1 (d) B1 For (a) and (b), allow verification, but must see full equations of motion.	
a	M1	Equation in T and a with correct no. of terms, condone sign errors and sin/cos confusion (If one of the 3's is missing, allow M1) N.B. Treat sin(3/5) etc as an A error but allow recovery
	A1	Correct equation (allow $(-a)$ instead of a in <u>both</u> equations)
b	M1	Correct no. of terms, condone sign errors and sin/cos confusion Allow if appears in (a)
	A1	Correct equation
	B1	Seen anywhere in (a) or (b), including on a diagram
	M1	Equation (for B) in T and a with correct no. of terms, condone sign errors and sin/cos confusion **OR Whole system equation** with correct no. of terms, condone sign errors and sin/cos confusion
	A1	Correct equation
	DM1	Complete method (trig may not be substituted), dependent on M1 in (a) and second M1 in (b) if they use two equations, or second M1 in (b) if they use one equation.
	A1*	Correct answer correctly obtained.
c	B1	Straight line starting at the origin (could be reflected in the t-axis). B0 if continuous vertical line at the end.
	DB1	Dependent on first B1, for any equivalent statement
d	B1	B0 if incorrect extras