This is a Class 1 exam

Lebanon Evangelical School for Boys and Girls

Lebanon Evangelical School

for Boys and Girls Loueizeh - Baabda

Stage Exam 02

26MAR2025

Do NOT write in this box. Your MARK will be placed here.

Subject :	A Level Maths : M1Mech
Class :	11A and 12A
Teacher :	Dr Ruth Brett
Duration :	1 hour

You may add to the diagrams on this paper, but no work written on this paper will be graded.
Remember that you must include sufficient working, or you may get no credit for a correct answer.

You are to answer the questions to this exam on : Squared paper

Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

1. Two particles, P and Q, with masses m and $2m$ respectively, are moving in the same direction along the same straight line when they collide directly. Immediately before they collide, P is moving with speed $4u$ and Q is moving with speed u. Immediately after they collide, both particles are moving in the same direction and the speed of Q is four times the speed of P.

(a) Find the speed of Q immediately after the collision.

(3)

(b) Find the magnitude of the impulse exerted by Q on P in the collision.

(3)

(Total for question = 6 marks)

2.

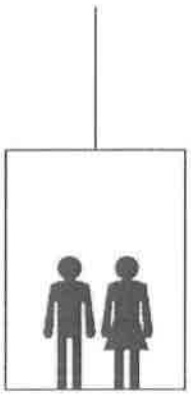


Figure 3

Two children, Alan and Bhavana, are standing on the horizontal floor of a lift, as shown in Figure 3.

The lift has mass 250 kg. The lift is raised vertically upwards with constant acceleration by a vertical cable which is attached to the top of the lift. The cable is modelled as being light and inextensible. While the lift is accelerating upwards, the tension in the cable is 3616 N.

As the lift accelerates upwards, the floor of the lift exerts a force of magnitude 565 N on Alan and a force of magnitude 226 N on Bhavana.

Air resistance is modelled as being negligible and Alan and Bhavana are modelled as particles.

(a) By considering the forces acting on the lift only, find the acceleration of the lift.

(4)

(b) Find the mass of Alan.

(3)

(Total for question = 6 marks)

3.

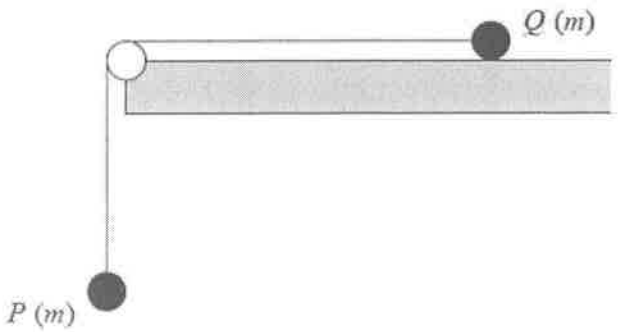


Figure 4

A particle P of mass m is attached to one end of a light inextensible string. Another particle Q, also of mass m, is attached to the other end of the string. The string passes over a small smooth pulley which is fixed at the edge of a rough horizontal table. Particle Q is held at rest on the table and particle P hangs vertically below the pulley with the string taut, as shown in Figure 4.

The pulley, P and Q all lie in the same vertical plane.

The coefficient of friction between Q and the table is μ, where $\mu < 1$

Particle Q is released from rest.

The tension in the string before Q hits the pulley is kmg, where k is a constant.

(a) Find k in terms of μ.

(7)

(Total for question = 7 marks)

4.

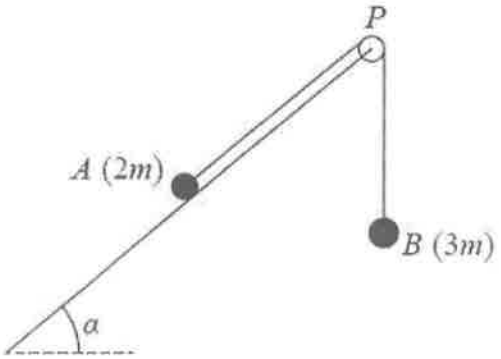


Figure 4

One end of a light inextensible string is attached to a particle A of mass $2m$. The other end of the string is attached to a particle B of mass $3m$. The string passes over a small, smooth, light pulley P which is fixed at the top of a rough inclined plane. The plane is inclined to the horizontal at an angle α, where:

$\tan \alpha = \frac{3}{4}$.

Particle A is held at rest on the plane with the string taut and B hanging freely below P, as shown in Figure 4. The section of the string AP is parallel to a line of greatest slope of the plane.

The coefficient of friction between A and the plane is 0.5.

Particle A is released and begins to move up the plane.

For the motion before A reaches the pulley,

(a) (i) write down an equation of motion for A,

(ii) write down an equation of motion for B,

(4)

(b) find, in terms of g, the acceleration of A,

(5)

(c) find the magnitude of the force exerted on the pulley by the string.

(4)

(d) State how you have used the information that P is a smooth pulley.

(1)

(Total for question = 14 marks)

5. Two small children, Ajaz and Beth, are running a 100 m race along a straight horizontal track.

They both start from rest, leaving the start line at the same time.

Ajaz accelerates at 0.8 m s^{-2} up to a speed of 4 m s^{-1} and then maintains this speed until he crosses the finish line.

Beth accelerates at 1 m s^{-2} for T seconds and then maintains a constant speed until she crosses the finish line.

Ajaz and Beth cross the finish line at the same time.

(a) Sketch, on the same axes, a speed-time graph for each child, from the instant when they leave the start line to the instant when they cross the finish line.

(3)

(b) Find the time taken by Ajaz to complete the race.

(4)

(c) Find the value of T

(4)

(d) Find the difference in the speeds of the two children as they cross the finish line.

(2)

(Total for question = 13 marks)

(1)



a) $m(4u) + 2m(u) = mv + 2m(4v)$ M(1) A(1)

$6mu = 9mv$

$v = \frac{6u}{9} = \frac{2u}{3}$

So speed of Q is $4\left(\frac{2u}{3}\right) = \frac{8u}{3}$ A(1)

b) $I = mv - mu$

Take ← as positive as this is the direction I acts in

For P $I = m\left(-\frac{2u}{3}\right) - m(-4u)$ M(1) A(1)

$I = 4mu - \frac{2mu}{3} = \frac{10}{3}mu$ A(1)

(2)



$R_A = 565N$

$R_B = 226N$

a) For the lift $R\uparrow$ $\Sigma F = ma$

$3616 - 250g - 565 - 226 = 250a$ M① A①

$250a = 375$ $\quad a = \frac{375}{250} = 1.5 ms^{-2}$ A①

b) for Alan $\Sigma F = ma$

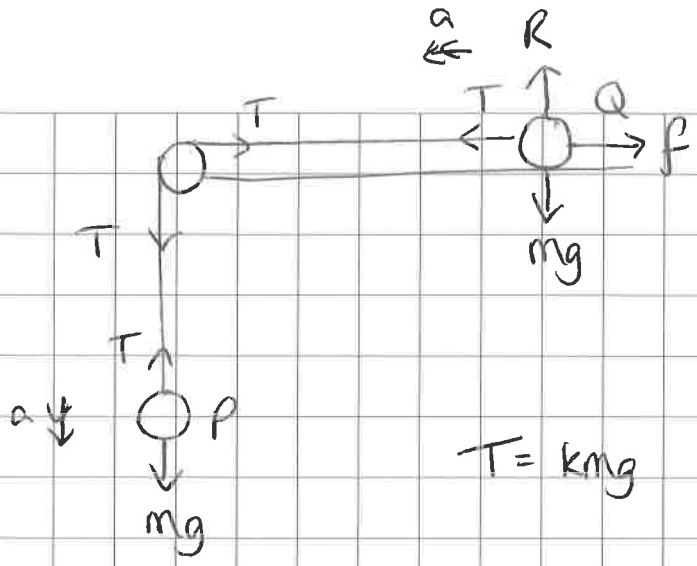
$R_A - m_A g = m_A a$

$565 - 9.8 m_A = 1.5 m_A$ M① A①

$11.3 m_A = 565$

$m_A = \frac{565}{11.3} = 50kg$ A①

3



$T = kmg$ $\quad \mu < 1$

For P $\quad R\downarrow \quad \Sigma F = ma$ $\quad$ m(1) A(1)

$mg - kmg = ma$ (1)

$g - kg = a$ (1)

for Q $\quad R\uparrow \quad R = mg$

$R\leftarrow \quad T - f = ma$

$f = \mu R = \mu mg$ A(1)

$kmg - \mu mg = ma$ m(1) A(1) (2)

$kg - \mu g = a$ (2)

Subs for a from (1) in (2)

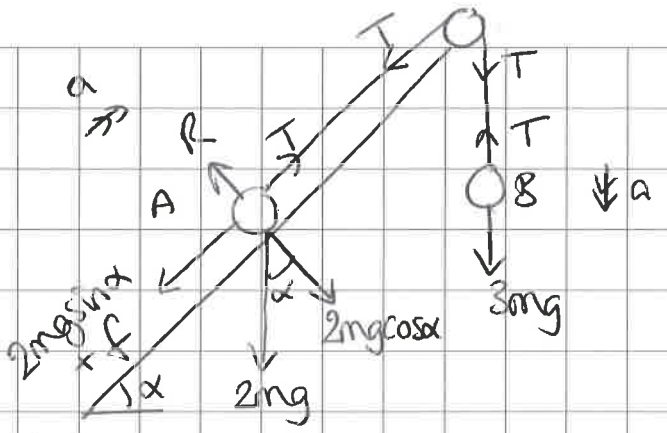
$kg - \mu g = g - kg$

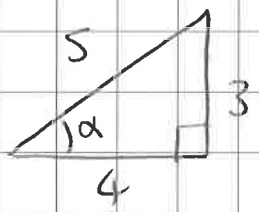
$\div g \quad k - \mu = 1 - k$ m(1)

$2k = 1 + \mu$

$k = \frac{1}{2}(1 + \mu)$ A(1)

4.





$\tan\alpha = \frac{3}{4}$

$\cos\alpha = \frac{4}{5}$ $\quad \sin\alpha = \frac{3}{5}$

a) i) For A $\quad \Sigma F = ma$

$T - 2mg\sin\alpha - f = 2ma$ ①

M① A①

ii) For B $\quad \Sigma F = ma$

$3mg - T = 3ma$ ②

M① A①

b) For A $\quad R\nwarrow \quad R = 2mg\cos\alpha$ M① A①

$f = \mu R = \frac{1}{2}(2mg\cos\alpha) = mg\cos\alpha = \frac{4}{5}mg$ A①

Subs for f in ① $\quad T - 2mg\left(\frac{3}{5}\right) - \frac{4}{5}mg = 2ma$

$T - \frac{6mg}{5} - \frac{4mg}{5} = 2ma$

$T - 2mg = 2ma$

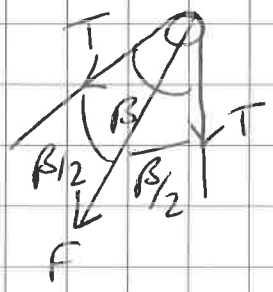
$T = 2ma + 2mg$

Subs for T in ② $\quad 3mg - 2ma - 2mg = 3ma$ M①

$mg = 5ma$

$a = \frac{g}{5}$ A①

4 c) $T = 2ma + 2mg = 2m\left(\frac{g}{5}\right) + 2mg = \frac{12mg}{5}$ M(1)



Angle $\beta = 90 - \alpha = 53.1°$

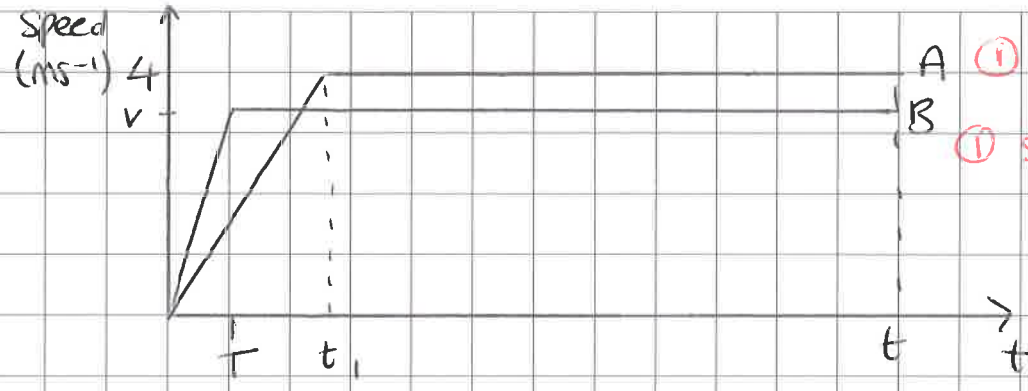
$\beta/2 = 26.565°$

$F = T\cos\frac{\beta}{2} + T\cos\frac{\beta}{2}$ M(1)

$F = 2\left(\frac{12mg}{5}\right)\cos 26.6 = 4.3mg$ M(1) A(1)

d) Tension is the same on both sides of the pulley. (1)

5.

a) 

① Shape of A

① Shape of B AND
- Steeper than A at start
- finishes at same time as A

① 4 and T labelled correctly.

b) For A $a = \frac{v-u}{t}$ $0.8 = \frac{4-0}{t_1}$ $t_1 = \frac{4}{0.8} = 5s$ A①

Distance = area under line

$\frac{1}{2}(t + (t-5))(4) = 100$ M① A①

$2t - 5 = \frac{100}{2}$ $2t = 55$ A① $t = 27.5s$

c) For B $v = u + at$ $v = 0 + (1)T$ $v = T$

Distance = area under the line

$\frac{1}{2}(27.5 + 27.5 - T)(v) = 100$ M① A①

But $v = T$ so $55T - T^2 = 200$

$T^2 - 55T + 200 = 0$ A① $T = 3.915$

$T = 3.92$ (3 sf) A①

d) $v_B = 3.92$

Difference in speeds = $4 - 3.915 = 0.085$ M① A①

$= 0.085s$ (2 sf)