This is a Class 1 exam

Lebanon Evangelical School
for Boys and Girls
Loueizeh - Baabda

Stage Exam 03
FEB2023

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 :	40 miniues

Write your answers in black pen on squared paper. Show your working. You may not be given full credit if your working is not seen. You may add to the diagrams on the exam paper. Where necessary, take g = 9.8 m/s^2.

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.

Q1. (Total 10 marks)

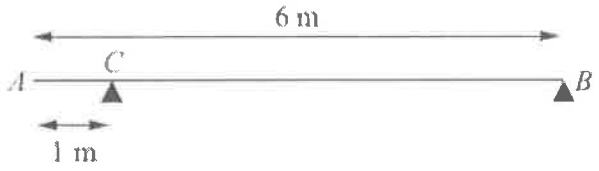


Figure 1

A uniform beam AB has mass 20 kg and length 6 m. The beam rests in equilibrium in a horizontal position on two smooth supports. One support is at C, where $AC = 1$ m, and the other is at the end B, as shown in Figure 1. The beam is modelled as a rod.

(a) Find the magnitudes of the reactions on the beam at B and at C.

(5)

* * * *(New situation: the beam stays the same, but the magnitudes of the reactions change)* * * *

A boy of mass 30 kg stands on the beam at the point D. The beam remains in equilibrium. The magnitudes of the reactions on the beam at B and at C are now equal. The boy is modelled as a particle.

(b) Find the distance AD.

(5)

Q2. (Total 9 marks)

A lorry is moving along a straight horizontal road with constant acceleration. The lorry passes a point A with speed u m s^{-1}, ($u < 34$), and 10 seconds later passes a point B with speed 34 m s^{-1}. Given that $AB = 240$ m, find

(a) the value of u,

(3)

(b) the time taken for the lorry to move from A to the mid-point of AB.

(6)

Q3. (Total 9 marks) [*In this question* **i** *and* **j** *are perpendicular unit vectors.*]

Three forces, $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$, are given by

$$\mathbf{F}_1 = (5\mathbf{i} + 2\mathbf{j}) \text{ N} \qquad \mathbf{F}_2 = (-3\mathbf{i} + \mathbf{j}) \text{ N} \qquad \mathbf{F}_3 = (a\mathbf{i} + b\mathbf{j}) \text{ N}$$

where a and b are constants.

The forces $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ act on a particle P.

(a) Given that P rests in equilibrium on a smooth horizontal surface under the action of these three forces, find the size of the angle between the direction of $\mathbf{F}_3$ and the direction of $-\mathbf{j}$.

(4)

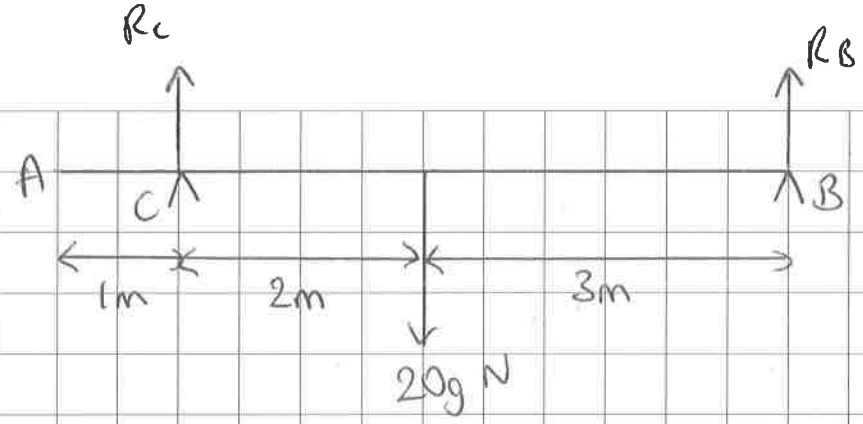
The force $\mathbf{F}_3$ is now removed and replaced by the force $\mathbf{F}_4$ given by $\mathbf{F}_4 = \lambda(\mathbf{i} + 3\mathbf{j})$ N, where λ is a positive constant.

Particle P has a mass of 4 kg.
When the three forces $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_4$ act on P, the acceleration of P has magnitude 3.25 m s^{-2}

(*b*) Find the value of λ.

(5)

1 a)



$R\uparrow \quad \Sigma F = 0$

$R_B + R_C = 20g$ m(1)

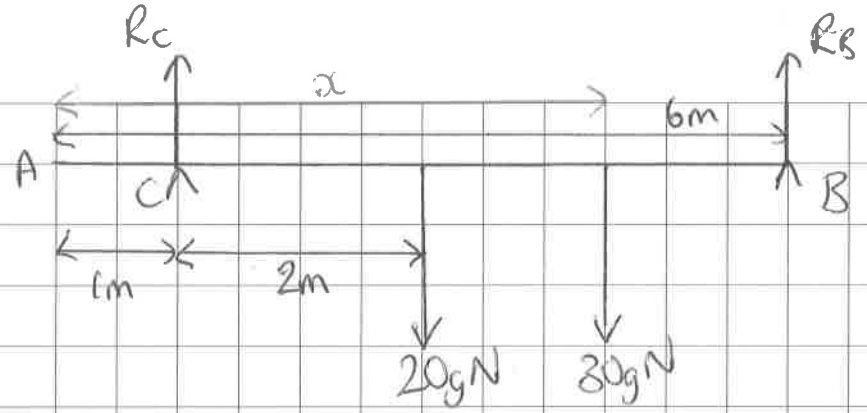
At C $\quad \Sigma \curvearrowright = \Sigma \curvearrowleft$

$5R_B = 2(20g)$ m(1) A(1)

$R_B = \frac{40g}{5} = 8g$ A(1)

$\therefore R_C = 20g - 8g = 12g$ A(1)

1 b)



$R_B = R_C$

$R\uparrow \quad \Sigma F = 0 \qquad R_C + R_B = 20g + 30g = 50g$ m ①

$\therefore R_B = R_C = 25g$

At A $\quad \Sigma \circlearrowleft = \Sigma \circlearrowright$

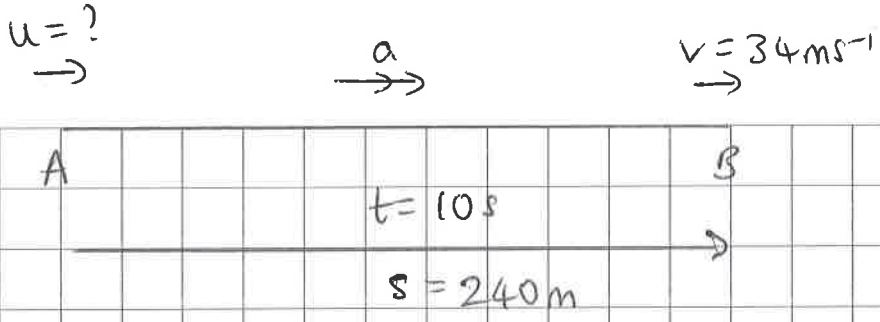
$20g\,(3) + 30g\,(x) = 25g\,(1) + 25g\,(6)$ m ① A ① A ①

Cancel g $\qquad 60 + 30x = 25 + 150$

$30x = 115$

$x = \frac{115}{30} = 3.83m$ A ①

2 a)

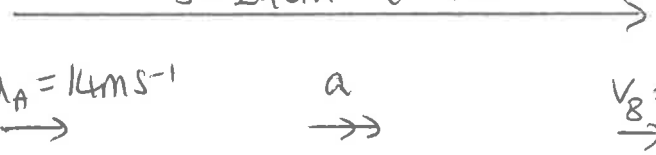


$$s = \left(\frac{u+v}{2}\right) t$$

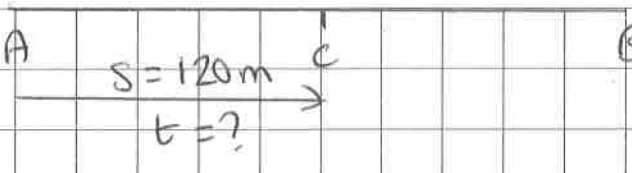
$$240 = \left(\frac{u+34}{2}\right)(10) \quad M(1) \quad A(1)$$

$$\frac{240}{5} = u + 34$$

$$u = 48 - 34 = 14 \text{ ms}^{-1} \quad A(1)$$



2 b)



We need to find either a or V_c before we can solve for t.

Find a from A → B $\quad v = u + at$

$34 = 14 + a(10)$ m①

$a = \frac{34 - 14}{10} = 2ms^{-2}$ A①

This is the same as a from A → C

Now we have $u = 14 \quad s = 120 \quad a = 2 \quad t = ?$

$s = ut + \frac{1}{2}at^2$

$120 = 14t + \frac{1}{2}(2)t^2$ m① A①

$t^2 + 14t - 120 = 0$ m①

$t = \frac{-14 \pm \sqrt{14^2 - 4(1)(-120)}}{2}$ $\quad t = \frac{-14 \pm 26}{2}$

$t = -20$ reject $\quad t = 6$ A①

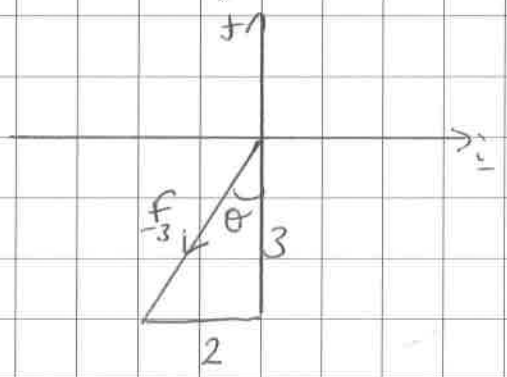
3 a) $\Sigma \underline{F} = 0 \qquad \underline{F}_1 + \underline{F}_2 + \underline{F}_3 = 0$

$(5\underline{i} + 2\underline{j}) + (-3\underline{i} + \underline{j}) + (a\underline{i} + b\underline{j}) = 0$ m①

$2\underline{i} + 3\underline{j} = -a\underline{i} - b\underline{j}$

$a = -2 \qquad b = -3$

$\underline{F}_3 = -2\underline{i} - 3\underline{j}$ A①



$\tan\theta = \frac{2}{3}$ m①

$\theta = 33.7°$ A①

3 b) $\Sigma \underline{F} = m\underline{a}$

$\Sigma \underline{F} = (5\underline{i} + 2\underline{j}) + (-3\underline{i} + \underline{j}) + (\lambda \underline{i} + 3\lambda \underline{j}) = (2+\lambda)\underline{i} + (3+3\lambda)\underline{j}$ m①

$|\underline{F}| = m|\underline{a}|$ since $\Sigma \underline{F} = m\underline{a} = 4\underline{a}$

$|\underline{F}| = 4|\underline{a}| = 4(3.25) = 13$ m① NOT $\underline{F} = 13$

m①

$\sqrt{(2+\lambda)^2 + (3+3\lambda)^2} = 13$

$(2+\lambda)(2+\lambda) + (3+3\lambda)(3+3\lambda) = 13^2 = 169$

$4 + \lambda^2 + 4\lambda + 9 + 9\lambda^2 + 18\lambda = 169$

$10\lambda^2 + 22\lambda - 156 = 0$ m①

$\lambda = \dfrac{-22 \pm \sqrt{22^2 - 4(10)(-156)}}{20} = \dfrac{-22 \pm 82}{20}$

$\lambda = \dfrac{60}{20} = 3$ A① $\lambda = -5.2$ reject since $\lambda > 0$