OCR
Oxford Cambridge and RSA

AS Level Mathematics B (MEI) H630/01 Pure Mathematics and Mechanics

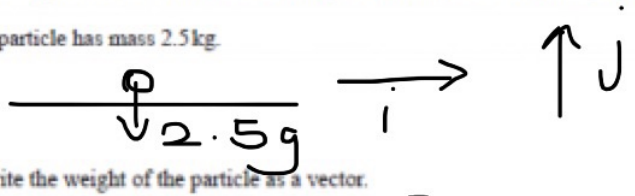
Question Set 4

1)

In this question, the unit vectors **i** and **j** are horizontal and vertically upwards respectively.

A particle has mass 2.5 kg.

a)

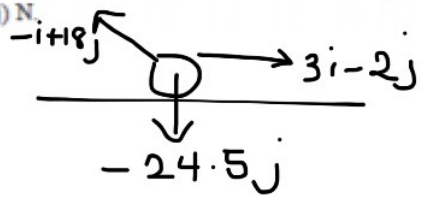


Write the weight of the particle as a vector. [1]

$2.5 \times 9.8 = 24.5$

$\therefore -24.5\mathbf{j}$

b) The particle moves under the action of its weight and two external forces $(3\mathbf{i} - 2\mathbf{j})$ N and $(-\mathbf{i} + 18\mathbf{j})$ N.



Find the acceleration of the particle, giving your answer in vector form. [2]

$\rightarrow +$ $F = ma$

$(3\mathbf{i} - 2\mathbf{j}) + (-\mathbf{i} + 18\mathbf{j}) = 2.5a$

$2\mathbf{i} + 16\mathbf{j} = 2.5a$

$\frac{2\mathbf{i} + 16\mathbf{j}}{2.5} = a$

$0.8\mathbf{i} + 6.4\mathbf{j} = a$

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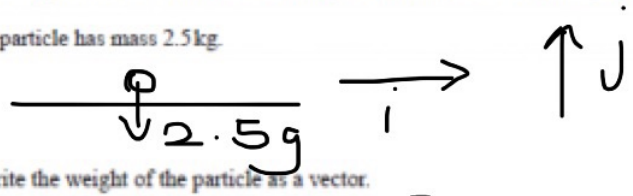

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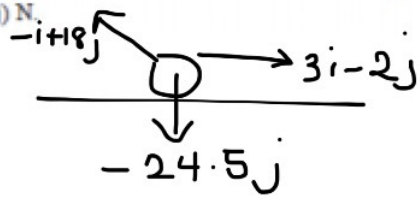

(c) The tension in the coupling between the engine and truck A is larger than that in the coupling between the trucks. Determine how much larger. [2]

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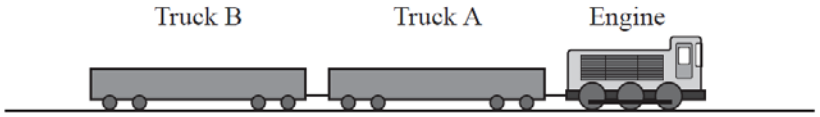
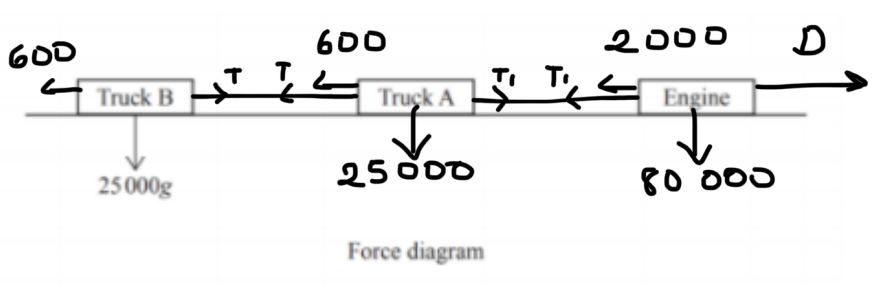
2 Fig. 2 shows a train consisting of an engine of mass 80 tonnes pulling two trucks each of mass 25 tonnes.



The engine exerts a driving force of D N and experiences a resistance to motion of 2000 N. Each truck experiences a resistance of 600 N. The train travels in a straight line on a level track with an acceleration of 0.1 $m\,s^{-2}$.

(a) Complete the force diagram below to show all the forces acting on the engine and each of the trucks. **[3]**



Force diagram

a = 0

(b) Calculate the value of D. **[2]**

overall mass = 80000 + 25000 + 25000
= 130000

D − 2000 − 600 − 600 = 130000 × 0.1
D = 13000 + 3200
D = 16200 N

(c) The tension in the coupling between the engine and truck A is larger than that in the coupling between the trucks. Determine how much larger. **[2]**

T − 600 = 0.1 × 2500
T = 850

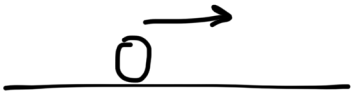
16200 − 2000 − T_1 = 80000 × 0.1
$-T_1 = -6200$
$T_1 = 6200$

$T_1 - T = 6200 - 850 = 5350$
∴ T_1 is 5350 N larger than T

3 **In this question you must show detailed reasoning.**

A car accelerates from rest along a straight level road. The velocity of the car after 8 s is $25.6\,\text{m s}^{-1}$.

In one model for the motion, the velocity $v\,\text{m s}^{-1}$ at time t seconds is given by $v = 1.2t^2 - kt^3$, where k is a constant and $0 \leqslant t \leqslant 8$.



(a) The model gives the correct velocity of $25.6\,\text{m s}^{-1}$ at time 8 s. Show that $k = 0.1$. **[2]**

$v = 1.2t^2 - kt^3$

at $t = 8$

$v = 25.6$

$25.6 = (1.2 \times 8^2) - (k \times 8^3)$

$-51.2 = -8^3 k$

$\frac{51.2}{8^3} = k$

$\frac{1}{10} = k$

$0.1 = k$

A second model for the motion uses constant acceleration.

(b) Find the value of the acceleration which gives the correct velocity of $25.6\,\text{m s}^{-1}$ at time 8 s. **[2]**

acceleration

S	
U	0
V	25.6
A	?
T	8

$v = u + at$

$25.6 = 0 + a \times 8$

$25.6 = 8a$

$\frac{25.6}{8} = a$

$3.2 = a$

(c) Show that these two models give the same value for the displacement in the first 8 s. **[5]**

model 1

S	?
U	0
V	$1.2t^2 - kt^3$
A	
T	8

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

$s = \frac{(0 + (1.2 \times 8^2 - 0.1 \times 8^3) \times 8)}{2}$

$s = \frac{204.8}{2}$

$s = 102.4\text{m}$

model 2

S	?
U	0
V	25.6
A	3.2
T	

$v^2 = u^2 + 2as$

$25.6^2 = 0^2 + 2 \times 3.2s$

$\frac{25.6^2}{2 \times 3.2} = s$

$102.4\text{m} = s$

∴ model 1 and 2 both produce 102.4 as displacement

Total Marks for Question Set 4: 19 marks