Topic assessment

1. A car of mass 1500 kg is pulling a trailer of mass 900 kg along a straight, horizontal road. The coupling between the car and the trailer is light, rigid and horizontal.

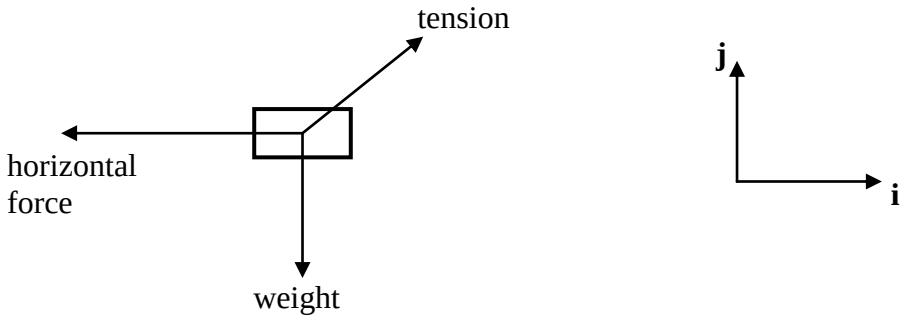
   The motion of the car and trailer is first modelled assuming that the resistances to motion are negligible. There is a driving force of 600 N acting on the car.

   (i) Draw separate diagrams showing the horizontal force(s) acting on
   (A) the car.
   (B) the trailer. [2]

   (ii) Calculate the acceleration of the car and trailer. Calculate also the force in the coupling, stating whether this is a tension or a thrust. [4]

2. In this question, the unit vector **i** is horizontal and the unit vector **j** is vertically upwards. All forces are in newtons.

   A small, heavy box is suspended in mid-air and is held in equilibrium by the tension in a light inextensible string and a horizontal force, as shown in the diagram.



   The tension in the string is $\mathbf{T}_1$, where $\mathbf{T}_1 = 30\mathbf{i} + 49\mathbf{j}$. The horizontal force is $\mathbf{F}_1$, where $\mathbf{F}_1 = p\mathbf{i}$.

   (i) Write down the value of p and show that the mass of the box is 5 kg. [2]

   (ii) Calculate the magnitude of $\mathbf{T}_1$ and the angle that $\mathbf{T}_1$ makes with the horizontal. [3]

   Another force $\mathbf{F}_2 = 48\mathbf{i} - 87\mathbf{j}$ is now applied to the box. The force $\mathbf{F}_1$ still acts and the box is still in equilibrium.

   (iii) The new tension in the string is $\mathbf{T}_2 = a\mathbf{i} + b\mathbf{j}$. Calculate the values of a and b. [3]

   The tension in the string now becomes $\mathbf{T}_3 = q(13\mathbf{i} + 84\mathbf{j})$, where q is a positive constant. The magnitude of this tension is 340 N. The forces $\mathbf{F}_1$ and $\mathbf{F}_2$ remain unaltered.

   (iv) Find the value of q. [2]
   Find also the acceleration of the box in ms^{-2}, giving your answer in the form $c\mathbf{i} + d\mathbf{j}$, where c and d are to be determined. [3]

Edexcel AS Maths Force Assessment solns

3. (a) Calculate the acceleration of an object of mass 150 kg subject to a net force of 60 N. [2]

(b) A load of mass 150 kg is accelerating vertically upwards as the result of the pull of a crane wire. The tension in the wire is 1488 N.

(i) Assuming that the only forces acting on the load are its weight and the tension in the wire, calculate the acceleration of the load. [2]

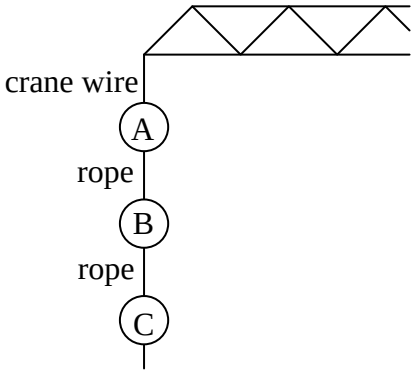
Measurements of the acceleration show that it actually has the value of only 0.05 ms^{-2}. This is because of resistance to the motion of the load.

(ii) Draw a diagram showing all the forces acting on the load.
Calculate the value of the resistance. [3]

In a new situation, the load is accelerating downwards at 4 ms^{-2} and the resistances to its motion are negligible.

(iii) Show that the tension in the crane wire is 870 N. [3]

The load consists of three iron rings A, B and C, each of mass 50 kg and attached to each other by inextensible light ropes, as shown in the diagram.



The rope connecting rings B and C breaks. The tension in the crane wire does not change.

(iv) Calculate the new acceleration of rings A and B and the tension in the rope joining them. [4]

4. A girl of mass 48 kg stands in a lift that is going upwards.
The lift initially accelerates at 2 ms^{-2} and then travels at a constant speed of 5 ms^{-1}.
Finally, the lift decelerates at 3 ms^{-2}.
The normal reaction of the floor of the lift on the girl is R N.

(i) Draw a diagram showing the weight of the girl and the normal reaction of the floor on her.
Write down the value of R while the lift is travelling at constant speed. [2]

(ii) Calculate the value of R when the lift is accelerating at 2 ms^{-2}. [3]

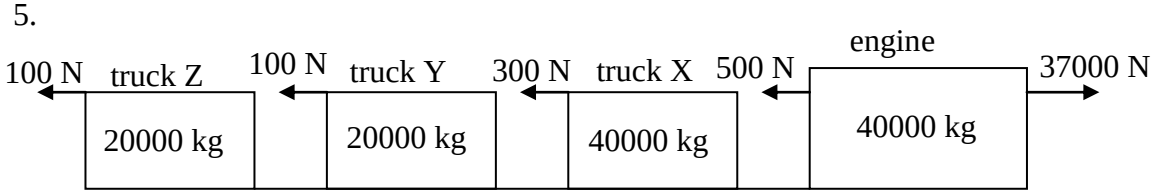
(iii) Calculate the value of R when the lift is decelerating at 3 ms^{-2}. [3]

The girl travels up in the lift on another occasion when she is holding a parcel of mass 5 kg by means of a light inextensible string. The lift moves as before.

(iv) The string does not break during the upwards motion. What force must the string be able to sustain?

Calculate also the value of the normal reaction of the floor of the lift on the girl (holding the parcel) while the lift is accelerating. [4]

5.



A train consists of an engine and three trucks with masses and resistance to motion as shown in the diagram. There is also a driving force of 37000 N. All the couplings are light, rigid and horizontal.

(i) Show that the acceleration of the train is 0.3 ms^{-2}. [3]

(ii) Draw a diagram showing all the forces acting on truck Z in the line of its motion. Calculate the force in the coupling between trucks Y and Z. [4]

With the driving force removed, brakes are applied, so adding a further resistance of 11000 N to the total of the resistances shown in the diagram.

(iii) Calculate the new acceleration of the train. [2]

(iv) Calculate the new force in the coupling between trucks Y and Z if the brakes are applied
(A) to the engine,
(B) to truck Z.

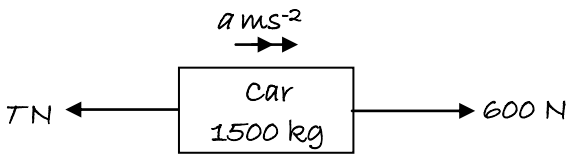
In each case state whether the force is a tension or a thrust. [6]

Total 60 marks

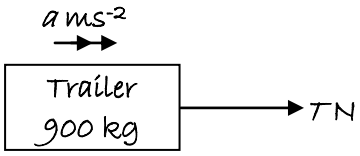
Edexcel AS Maths Force Assessment solns

Solutions to topic assessment

1. (i) (A)



(B)



[2]

(ii) For the whole system: $600 = 2400a$

$a = 0.25$

The acceleration is 0.25 ms^{-2}.

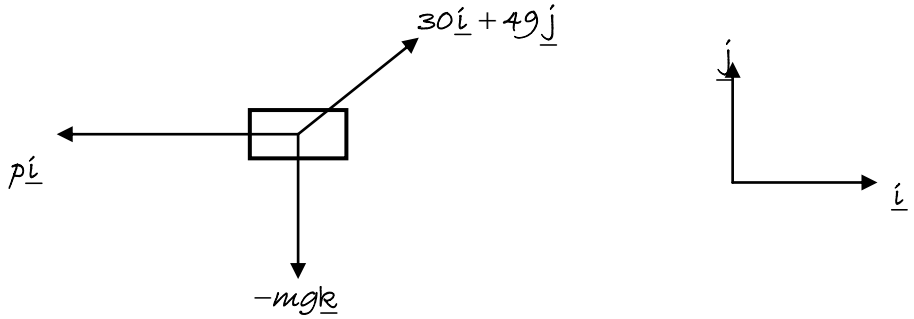
For the trailer only: $T = 900 \times 0.25$

$= 225$

The force in the coupling is a tension of 225 N.

[4]

2.



(i) Considering the horizontal equilibrium: $p = -30$

Considering the vertical equilibrium: $9.8m = 49 \Rightarrow m = 5$

so the mass of the box is 5 kg.

[2]

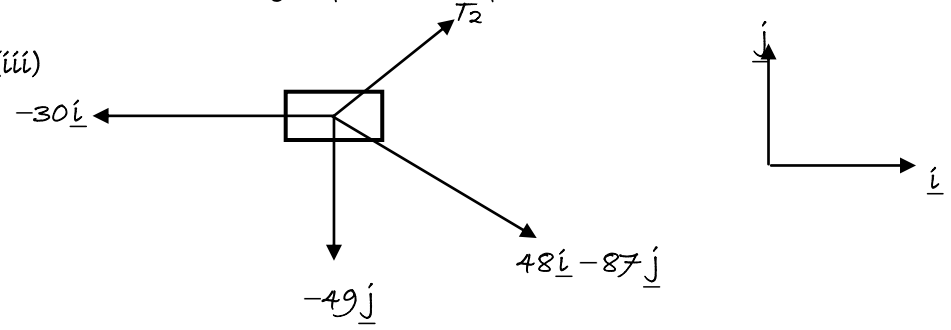
(ii) $|T_1| = \sqrt{30^2 + 49^2} = 57.5$ (3 s.f.)

$\tan\theta = \frac{49}{30} \Rightarrow \theta = 58.5°$ (3 s.f.)

T_1 makes an angle of 58.5° (3 s.f.) with the horizontal.

[3]

(iii)



Since the box is in equilibrium: $T_2 + 48\underline{i} - 87\underline{j} - 49\underline{j} - 30\underline{i} = 0$

$T_2 = -18\underline{i} + 136\underline{k}$

$a = -18,\ b = 136$

[3]

(iv) $q^2\left(13^2 + 84^2\right) = 340^2$

$q = 4$

[2]

Total force acting on box $= 4\left(13\underline{i} + 84\underline{j}\right) + 48\underline{i} - 87\underline{j} - 49\underline{j} - 30\underline{i}$

$= 70\underline{i} + 200\underline{j}$

Newton's 2nd law: $70\underline{i} + 200\underline{j} = 5\underline{a}$

$\underline{a} = 14\underline{i} + 40\underline{j}$

[3]

3. (a) $F = ma$

$60 = 150a$

$a = 0.4$

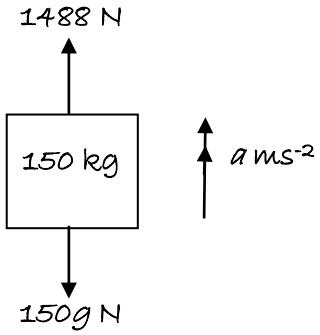
The acceleration is 0.4 ms^{-2}.

[2]

(i) (i) $1488 - 150 \times 9.8 = 150a$

$18 = 150a$

$a = 0.12$



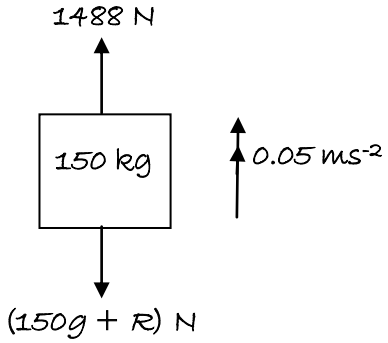
[2]

(ii) $1488 - 150 \times 9.8 - R = 150 \times 0.05$

$18 - R = 7.5$

$R = 10.5$

The resistance is 10.5 N.



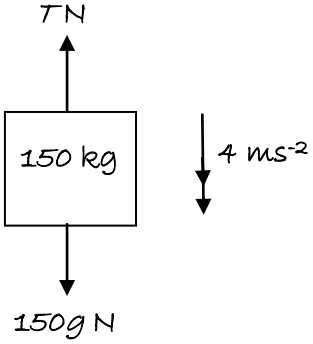
[3]

(iii) $150 \times 9.8 - T = 150 \times 4$

$1470 - T = 600$

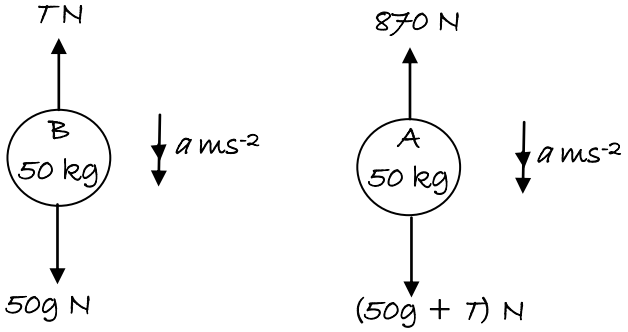
$T = 870$

The tension is 870 N.



[3]

(iv)



For A and B together: $100 \times 9.8 - 870 = 100a$

$110 = 100a$

$a = 1.1$

The acceleration of the rings is 1.1 ms^{-2} downwards.

For B only: $50 \times 9.8 - T = 50 \times 1.1$

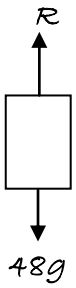
$490 - T = 55$

$T = 435$

The tension in the rope is 435 N.

[4]

4. (i)



When lift is travelling at constant speed, acceleration is zero

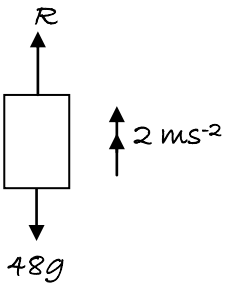
so $R - 48g = 0$

$R = 48 \times 9.8 = 470.4$

[2]

(ii) $R - 48g = 48 \times 2$

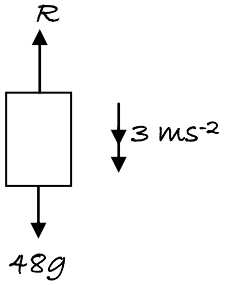
$R = 470.4 + 96 = 566.4$



[3]

(iii) $R - 48g = -48 \times 3$

$R = 470.4 - 144 = 326.4$

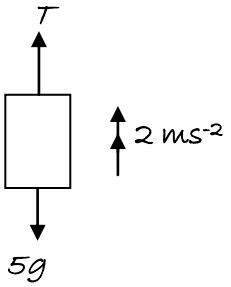


[3]

(iv) $T - 5g = 5 \times 2$

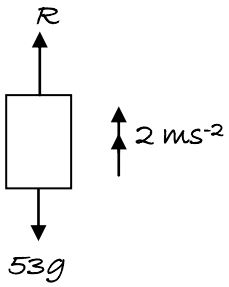
$T = 49 + 10 = 59$

The string must be able to sustain a force of 59 N.



$R - 53g = 53 \times 2$

$R = 519.4 + 106 = 625.4$



[4]

5. (i) Applying Newton's 2nd law to the whole train:

$37000 - 500 - 300 - 100 - 100 = (40000 + 40000 + 20000 + 20000)a$

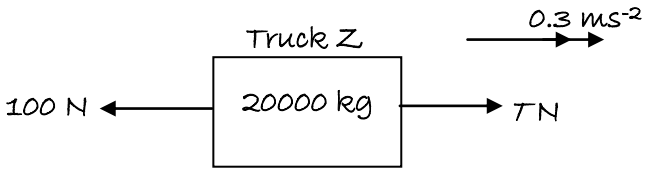
$36000 = 120000a$

$a = 0.3$

The acceleration of the train is 0.3 ms^{-2}

[3]

(ii)



Applying Newton's 2nd law to truck Z:

$T - 100 = 20000 \times 0.3$

$T - 100 = 6000$

$T = 6100$

The force in the coupling between Y and Z is a tension of 6100 N.

[4]

(iii) Applying Newton's 2nd law to the whole train:

$-11000 - 500 - 300 - 100 - 100 = 120000a$

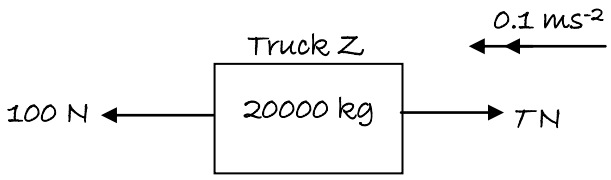
$-12000 = 120000a$

$a = -0.1$

The new acceleration is -0.1 ms^{-2}.

[2]

(iv) (A)



Applying Newton's 2nd law to truck Z:

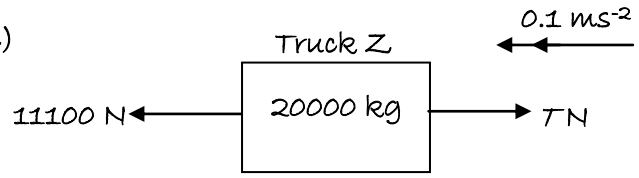
$100 - T = 20000 \times 0.1$

$T = 100 - 2000$

$T = -1900$

The force in the coupling is a thrust of 1900 N.

(B)



Applying Newton's 2nd law to truck Z:

$11100 - T = 20000 \times 0.1$

$T = 11100 - 2000$

$T = 9100$

The force in the coupling is a tension of 9100 N.

[6]