A-LEVEL MATHS INTRODUCTION – CONNECTED PARTICLES

MECHS I JAN 99.

(2)

1 A tractor of mass 1600 kg is pulling a trailer of mass 800 kg along a level muddy field. The driving force of the tractor is 7000 N and the resistances to motion acting on the tractor and trailer are 1000 N and 1200 N respectively.

(i) Show that the common acceleration of the tractor and trailer is $2\,m\,s^{-2}$ in the direction of their motion. [3]

The tractor and the trailer are connected by a light, horizontal coupling, as shown in Fig. 1.

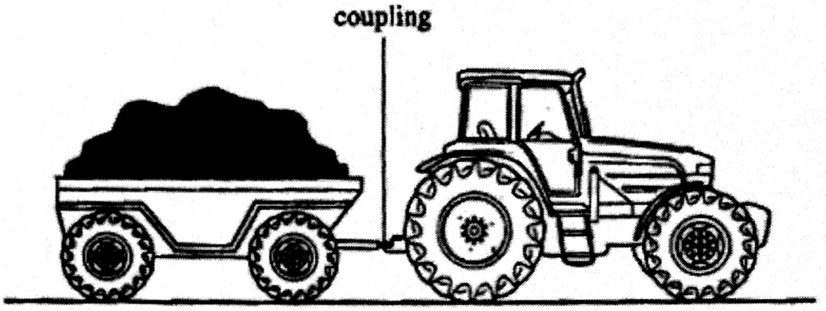

Fig. 1

(ii) Calculate the tension in the coupling. [3]

The coupling between the tractor and the trailer breaks at the time when the speed is $2.7\,m\,s^{-1}$. Assume that the resistances to motion and the driving force of the tractor do not change.

(iii) (A) Show that the deceleration of the trailer is $1.5\,m\,s^{-2}$. [2]

4 A car and its trailer travel along a straight, horizontal road. The coupling between them is light and horizontal. The car has mass 900 kg and resistance to motion 100 N, the trailer has mass 700 kg and resistance to motion 300 N, as shown in Fig. 4. The car and trailer have an acceleration of $1.5\,m\,s^{-2}$.

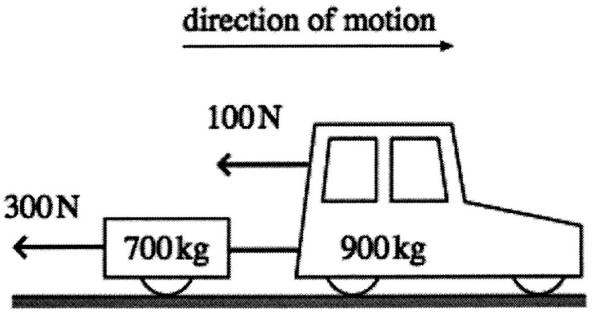

Fig. 4

(i) Calculate the driving force of the car. [3]

(ii) Calculate the force in the coupling. [2]

3 (a)

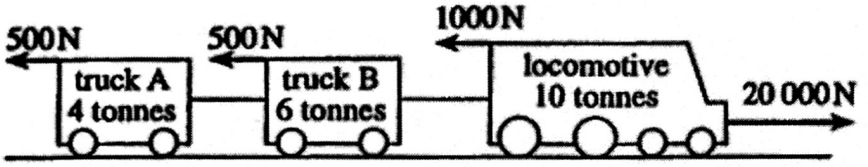

Fig. 3

A locomotive and two trucks are travelling along a straight, level track. Their masses, in tonnes, resistances to motion and the driving force of 20 000 N on the locomotive are shown in Fig. 3. The couplings between the locomotive and truck B and between trucks A and B are light and horizontal.

(i) Show that the acceleration of the locomotive and trucks is 0.9 m s^{-2}. [3]

(ii) Calculate the force in the coupling between the trucks. [3]

The driving force changes but the resistances remain as before. The tension in the coupling between the trucks is now 5500 N.

(iii) Calculate the new values of the acceleration and of the driving force. [5]

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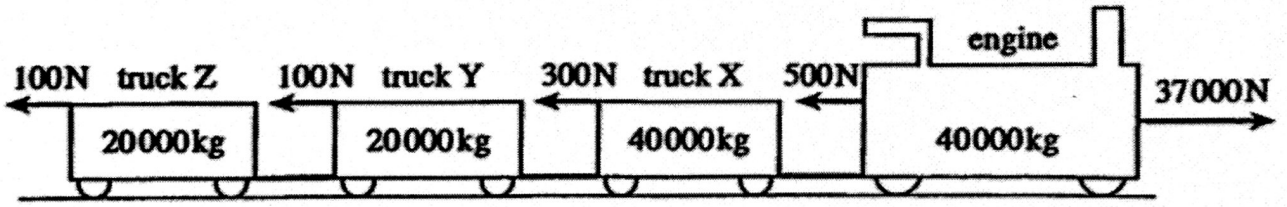

Fig. 1

A train consists of an engine and three trucks with masses and resistances to motion as shown in Fig. 1. There is also a driving force of 37 000 N. All the couplings are light, rigid and horizontal.

(i) Show that the acceleration of the train is 0.3 m s^{-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 11 000 N to the total of the resistances shown in Fig. 1.

(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]

3 A child is pulling a toy lorry and trailer along a horizontal garden path by means of a light horizontal string. The lorry and trailer have masses 3.5 kg and 1.5 kg and are subject to resistances to motion of 6 N and 4 N respectively. The coupling between the lorry and the trailer is light, rigid and horizontal. This situation is shown in Fig. 3.

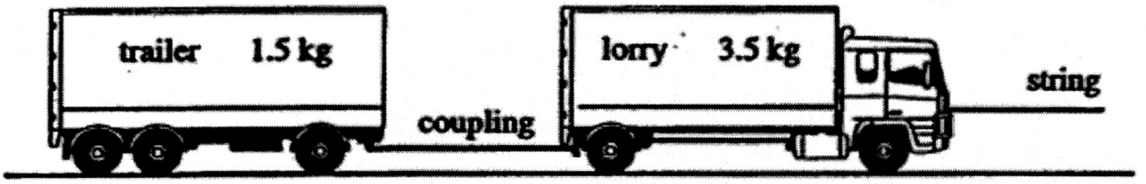

Fig. 3

The tension in the string is 20 N.

(i) Draw a diagram showing all the horizontal forces acting on the lorry and on the trailer, including the force in the coupling. Calculate the acceleration of the lorry and trailer. [4]

(ii) Calculate the force in the coupling. [2]

The child's father decides to join in the game by pushing the trailer forwards with a horizontal force. The child pulls the string with the same force as before and the resistances to motion are unchanged. The force in the coupling is now a thrust (compression) of 1.75 N.

(iii) Calculate the force with which the father is pushing. [5]

4 Two trucks, A and B, each of mass 10 000 kg, are pulled along a straight, horizontal track by a constant, horizontal force of P N. The coupling between the trucks is light and horizontal. This situation and the resistances to motion of the trucks are shown in Fig. 4.

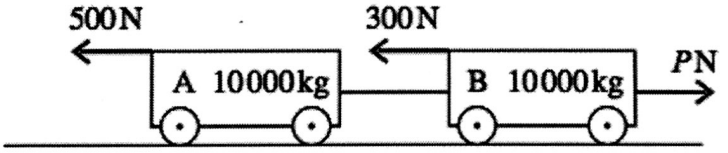

Fig. 4

The acceleration of the system is 0.2 m s^{-2} in the direction of the pulling force of magnitude P.

(i) Calculate the value of P. [3]

Truck A is now subjected to an extra resistive force of 2000 N while P does not change.

(ii) Calculate the new acceleration of the trucks. [2]

(iii) Calculate the force in the coupling between the trucks. [2]