Godalming College

Mechanics 6 – Connected Particles

Please **complete** this homework by _____. Start it early. If you can't do a question you will then have time to ask your teacher for help or go to a drop in session.

Section 1 – Review of previous topics. Please complete all questions.

A particle moving with speed v m s^{-1} in direction **d** has velocity vector **v**. Find **v** for these.

a $v = 10$, $\mathbf{d} = 3\mathbf{i} - 4\mathbf{j}$

b $v = 15$, $\mathbf{d} = -4\mathbf{i} + 3\mathbf{j}$

c $v = 7.5$, $\mathbf{d} = -6\mathbf{i} + 8\mathbf{j}$

d $v = 5\sqrt{2}$, $\mathbf{d} = \mathbf{i} + \mathbf{j}$

e $v = 2\sqrt{13}$, $\mathbf{d} = -2\mathbf{i} + 3\mathbf{j}$

f $v = \sqrt{68}$, $\mathbf{d} = 3\mathbf{i} - 5\mathbf{j}$

g $v = \sqrt{60}$, $\mathbf{d} = -4\mathbf{i} - 2\mathbf{j}$

h $v = 15$, $\mathbf{d} = -\mathbf{i} + 2\mathbf{j}$

Section 2 – Consolidation of this week's topic. Please complete all questions.

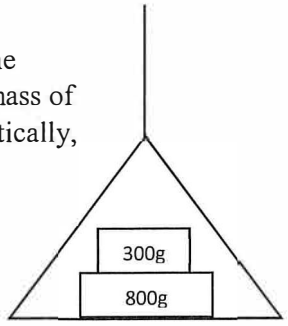
1. An engine of mass 60 tonnes pulls a truck of mass 12 tonnes along a horizontal track. The engine experiences a resistance to motion of 80 N per kg and the truck a resistance of 50 N per kg. Given that the train is travelling at constant speed, find the driving force of the engine and the tension in the coupling between engine and truck.

(7 marks)

2. An engine of mass 50 tonnes pulls a train of mass 200 tonnes along a horizontal track. The resistance to the motion for the engine is 3000 N and the resistance to motion for the train is 7000 N. The engine is exerting a driving force of 60000 N. Find the acceleration of the system and the tension in the coupling between the engine and the train.

(7 marks)

3. A light scale-pan is attached to a vertical light inextensible string. The scale-pan carries two masses A and B. The mass A is 300 g and the mass of B is 800 g. A rests on top of B as shown. The scale-pan is raised vertically, using the string, with acceleration 1.5 ms^{-2}. Find
   (a) the tension in the string,
   (b) the force exerted on mass B by mass A,
   (c) the force exerted on mass B by the scale-pan.



(3 + 3 + 3 = 9 marks)

4. A car is towing a trailer along a straight horizontal road by means of a horizontal tow-rope. The mass of the car is 1400 kg. The mass of the trailer is 700 kg. The car and the trailer are modelled as particles and the tow-rope as a light inextensible string. The resistances to motion of the car and the trailer are assumed to be constant and of magnitude 630 N and 280 N respectively. The driving force on the car, due to its engine, is 2380 N. Find

   (*a*) the acceleration of the car,

   (3)

   (*b*) the tension in the tow-rope.

   (3)

(continued over)

When the car and trailer are moving at 12 m s^{-1}, the tow-rope breaks. Assuming that the driving force on the car and the resistances to motion are unchanged,

(*c*) find the distance moved by the car in the first 4 s after the tow-rope breaks.

(6)

(*d*) State how you have used the modelling assumption that the tow-rope is inextensible.

(1)

(Total 36 marks)

Section 3 – Extension questions. If you are aiming for a top grade, you should attempt these questions.

Past exam Questions

M1 May 2013

A woman travels in a lift. The mass of the woman is 50 kg and the mass of the lift is 950 kg. The lift is being raised vertically by a vertical cable which is attached to the top of the lift. The lift is moving upwards and has constant deceleration of 2 m s^{-2}. By modelling the cable as being light and inextensible, find

(*a*) the tension in the cable,

(*b*) the magnitude of the force exerted on the woman by the floor of the lift.

M1 May 2012

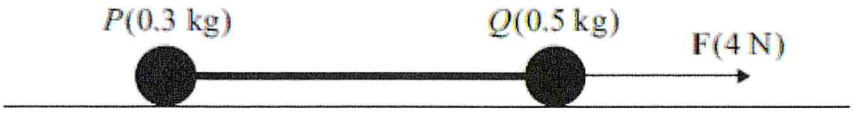


Figure 1

Two particles *P* and *Q*, of mass 0.3 kg and 0.5 kg respectively, are joined by a light horizontal rod. The system of the particles and the rod is at rest on a horizontal plane.

At time $t = 0$, a constant force **F** of magnitude 4 N is applied to *Q* in the direction *PQ*, as shown in Figure 1. The system moves under the action of this force until $t = 6$ s. During the motion, the resistance to the motion of *P* has constant magnitude 1 N and the resistance to the motion of *Q* has constant magnitude 2 N.

Find

(*a*) the acceleration of the particles as the system moves under the action of **F**,

(*b*) the speed of the particles at $t = 6$ s,

(*c*) the tension in the rod as the system moves under the action of **F**.

At $t = 6$ s, **F** is removed and the system decelerates to rest. The resistances to motion are unchanged. Find

(*d*) the distance moved by P as the system decelerates,

(*e*) the thrust in the rod as the system decelerates.