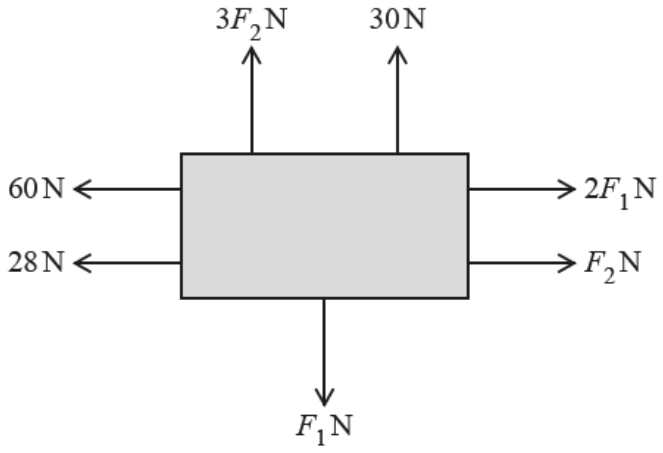
Forces and Newton's laws – 2021/20 GCE AS Mechanics Mathematics A

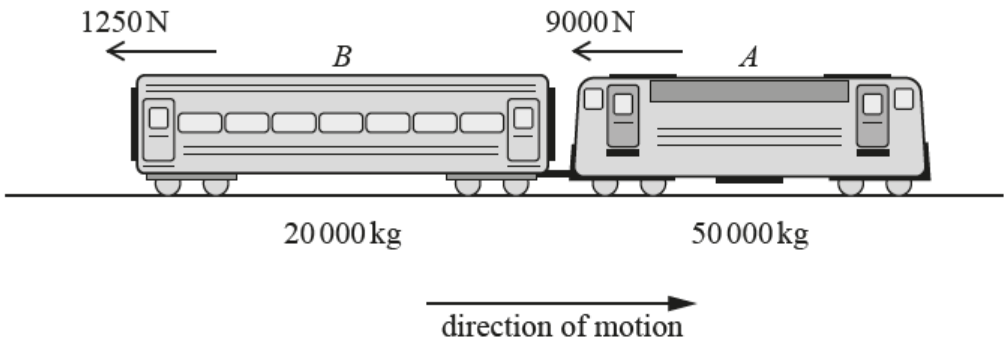
1. Oct/2021/Paper_H230/02/No.9



A body remains at rest when subjected to the horizontal and vertical forces shown in the diagram.

Determine the value of F_1 and the value of F_2. **[3]**

2. Oct/2021/Paper_H230/02/No.11



A train consists of an engine A of mass 50 000 kg and a carriage B of mass 20 000 kg. The engine and carriage are connected by a rigid coupling. The coupling is modelled as light and horizontal.

The resistances to motion acting on A and B are 9000 N and 1250 N respectively (see diagram).

The train passes through station P with speed $15\,\text{m s}^{-1}$ and moves along a straight horizontal track with constant acceleration $0.01\,\text{m s}^{-2}$ towards station Q. The distance between P and Q is 12.95 km.

(a) Determine the time, in minutes, to travel between P and Q. **[3]**

For the train's motion between P and Q, determine the following.

(b) The driving force of the engine. **[2]**

(c) The tension in the coupling between A and B. **[2]**

3. Oct/2020/Paper_H230/02/No.8

A particle is in equilibrium under the action of the following three forces:

$(2p\mathbf{i} - 4\mathbf{j})$ N, $(-3q\mathbf{i} + 5p\mathbf{j})$ N and $(-13\mathbf{i} - 6\mathbf{j})$ N.

Find the values of p and q. **[3]**

4. Oct/2020/Paper_H230/02/No.9

A crane lifts a car vertically. The car is inside a crate which is raised by the crane by means of a strong cable. The cable can withstand a maximum tension of 9500 N without breaking. The crate has a mass of 55 kg and the car has a mass of 830 kg.

(a) Find the maximum acceleration with which the crate and car can be raised. **[2]**

(b) Show on a clearly labelled diagram the forces acting on the **crate** while it is in motion. **[1]**

(c) Determine the magnitude of the reaction force between the crate and the car when they are ascending with maximum acceleration. **[3]**

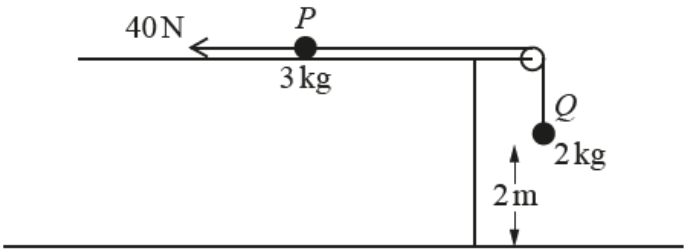
5. June/2019/Paper_H230/02/No.9

Three forces $\begin{pmatrix} 7 \\ -6 \end{pmatrix}$ N, $\begin{pmatrix} 2 \\ 5 \end{pmatrix}$ N and $\mathbf{F}$ N act on a particle.

Given that the particle is in equilibrium under the action of these three forces, calculate $\mathbf{F}$. **[2]**

6. June/2019/Paper_H230/02/No.11

Two small balls P and Q have masses 3 kg and 2 kg respectively. The balls are attached to the ends of a string. P is held at rest on a rough horizontal surface. The string passes over a pulley which is fixed at the edge of the surface. Q hangs vertically below the pulley at a height of 2 m above a horizontal floor.



The system is initially at rest with the string taut. A horizontal force of magnitude 40 N acts on P as shown in the diagram.

P is released and moves directly away from the pulley. A constant frictional force of magnitude 8 N opposes the motion of P. It is given that P does not leave the horizontal surface and that Q does not reach the pulley in the subsequent motion.

The balls are modelled as particles, the pulley is modelled as being small and smooth, and the string is modelled as being light and inextensible.

(a) Show that the magnitude of the acceleration of each particle is $2.48\,\text{m s}^{-2}$. **[5]**

(b) Find the tension in the string. **[2]**

When the balls have been in motion for 0.5 seconds, the string breaks.

(c) Find the additional time that elapses until Q hits the floor. **[5]**

(d) Find the speed of Q as it hits the floor. **[2]**

(e) Write down the magnitude of the normal reaction force acting on Q when Q has come to rest on the floor. **[1]**

(f) State one improvement that could be made to the model. **[1]**