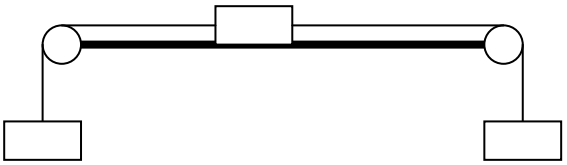
Section 3: Connected objects

Exercise level 2

Take g = 9.8 ms^{-2} throughout this exercise.

1. A mass of 10 kg lies on a smooth horizontal table. It is connected by a light inextensible string passing over a smooth pulley at one side of the table to a mass of 8 kg that hangs freely. The 10 kg mass is also connected by light inextensible string passing over a smooth pulley at the opposite edge of the table to a mass of 5 kg that hangs freely also.



(i) Draw a diagram showing all of the forces acting on the three masses.
(ii) If the system is released from rest, find the acceleration of the system and the tensions in the strings.

2. A particle of mass *m* rests on a smooth horizontal table. It is connected by a light inextensible string which passes over a smooth pulley at the edge of the table to a particle of mass *m* that hangs freely. The system is released from rest. Find the distance travelled and the speed at the end of the first 0.5 seconds of motion.

3. A package of mass 4 kg rests on a smooth horizontal shelf 2.5 m from the edge. It is connected by a light inextensible string which passes over a smooth pulley at the edge of the shelf to a particle of mass 0.5 kg that hangs freely. The system is released from rest. Find the speed of the 4 kg mass as it reaches the edge of the shelf. You may assume that the 0.5 kg mass does not reach the floor during the motion.

4. Consider a system identical to that in question 3 except that the shelf is not smooth. The 4 kg mass experiences a frictional force of 2 N. What speed does the 4 kg mass reach now at the edge of the shelf?

5. A car of mass 900 kg is pulling a caravan of mass 700 kg by means of a tow-bar along a straight horizontal road. The resistive forces opposing the motions of the car and the caravan are 120 N and 70 N respectively. When the car is accelerating at 0.4 ms^{-2}, calculate, in Newtons,
   (i) the tension in the tow-bar
   (ii) the force being produced by the engine of the car.

6. Particles of mass 700 g and 500 g are connected by a light inextensible string passing over a smooth pulley. Initially both masses hang vertically, 20 cm above the ground. If the system is released from rest, find the greatest height reached above the ground by the 500 g mass.

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7. Two light scale pans, *A* and *B*, are connected by a light cord which hangs over a smooth peg. Two particles of mass *pm* and *qm* are placed on *A* and *B*, respectively and the system is released from rest. In the resulting motion, *A* moves downwards with acceleration $\frac{g}{2}$.

   (a) (i) Find in terms of *p*, *m* and *g*, the tension in the string.
   (ii) Show that $p = 3q$

   (b) The particles of mass *pm* and *qm* are then both placed on the scale pan *A* and a particle of mass *4m* is placed on *B*. The system is again released from rest and A again accelerates downwards at a rate of $\frac{g}{2}$.

   (i) By using the result in part (a) (ii), or otherwise, find another equation in *p* and *q*
   (ii) Hence find the values of *p* and *q*.