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Mechanics

TOPIC- FORCES-EQUILIBRIUM

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Forces-Equilibrium

1 A block of mass 400 kg rests in limiting equilibrium on horizontal ground. A force of magnitude 2000 N acts on the block at an angle of 15° to the upwards vertical. Find the coefficient of friction between the block and the ground, correct to 2 significant figures. [5]

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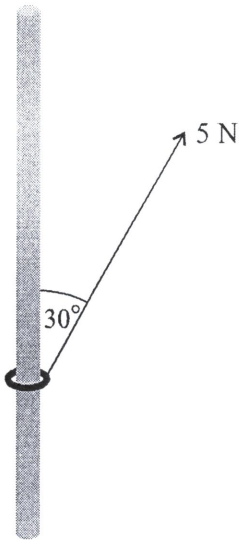

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A small ring of mass 0.6 kg is threaded on a rough rod which is fixed vertically. The ring is in equilibrium, acted on by a force of magnitude 5 N pulling upwards at 30° to the vertical (see diagram).

(i) Show that the frictional force acting on the ring has magnitude 1.67 N, correct to 3 significant figures. [2]

(ii) The ring is on the point of sliding down the rod. Find the coefficient of friction between the ring and the rod. [3]

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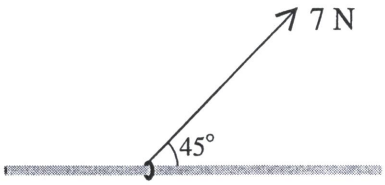

A small ring of mass 0.8 kg is threaded on a rough rod which is fixed horizontally. The ring is in equilibrium, acted on by a force of magnitude 7 N pulling upwards at 45° to the horizontal (see diagram).

(i) Show that the normal component of the contact force acting on the ring has magnitude 3.05 N, correct to 3 significant figures. [2]

(ii) The ring is in limiting equilibrium. Find the coefficient of friction between the ring and the rod. [3]

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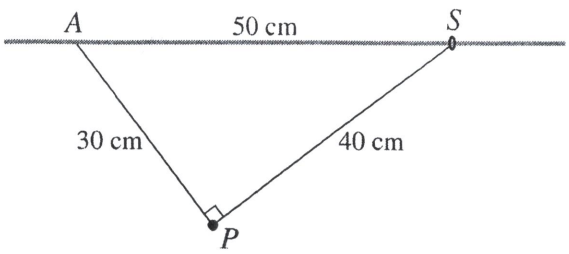

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A particle P of weight 5 N is attached to one end of each of two light inextensible strings of lengths 30 cm and 40 cm. The other end of the shorter string is attached to a fixed point A of a rough rod which is fixed horizontally. A small ring S of weight W N is attached to the other end of the longer string and is threaded on to the rod. The system is in equilibrium with the strings taut and $AS = 50$ cm (see diagram). N-9

(i) By resolving the forces acting on P in the direction of PS, or otherwise, find the tension in the longer string. [3]

(ii) Find the magnitude of the frictional force acting on S. [2]

(iii) Given that the coefficient of friction between S and the rod is 0.75, and that S is in limiting equilibrium, find the value of W. [3]

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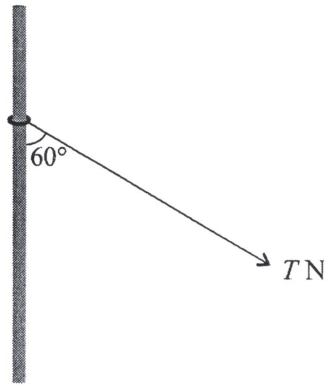

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A ring of mass 4 kg is threaded on a fixed rough vertical rod. A light string is attached to the ring, and is pulled with a force of magnitude TN acting at an angle of 60° to the downward vertical (see diagram). The ring is in equilibrium.

(i) The normal and frictional components of the contact force exerted on the ring by the rod are RN and FN respectively. Find R and F in terms of T. [4]

(ii) The coefficient of friction between the rod and the ring is 0.7. Find the value of T for which the ring is about to slip. [3]

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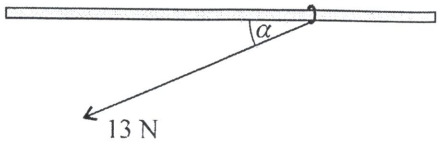

A ring of mass 1.1 kg is threaded on a fixed rough horizontal rod. A light string is attached to the ring and the string is pulled with a force of magnitude 13 N at an angle α below the horizontal, where $\tan\alpha = \frac{5}{12}$ (see diagram). The ring is in equilibrium.

(i) Find the frictional component of the contact force on the ring. [2]

(ii) Find the normal component of the contact force on the ring. [2]

(iii) Given that the equilibrium of the ring is limiting, find the coefficient of friction between the ring and the rod. [1]

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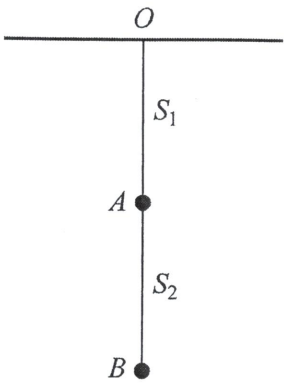

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S_1 and S_2 are light inextensible strings, and A and B are particles each of mass 0.2 kg. Particle A is suspended from a fixed point O by the string S_1, and particle B is suspended from A by the string S_2. The particles hang in equilibrium as shown in the diagram.

(i) Find the tensions in S_1 and S_2. [3]

The string S_1 is cut and the particles fall. The air resistance acting on A is 0.4 N and the air resistance acting on B is 0.2 N.

(ii) Find the acceleration of the particles and the tension in S_2. [5]

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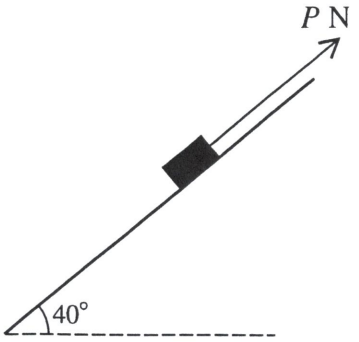

Fig. 1

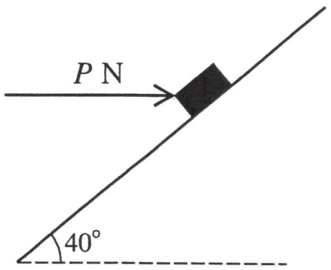

Fig. 2

A small block of weight 12 N is at rest on a smooth plane inclined at 40° to the horizontal. The block is held in equilibrium by a force of magnitude P N. Find the value of P when N-9-42

(i) the force is parallel to the plane as in Fig. 1, [2]

(ii) the force is horizontal as in Fig. 2. [2]

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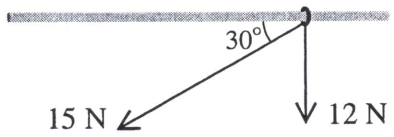

Fig. 1

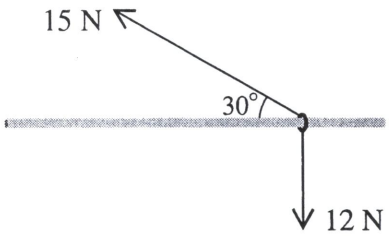

Fig. 2

A small ring of weight 12 N is threaded on a fixed rough horizontal rod. A light string is attached to the ring and the string is pulled with a force of 15 N at an angle of 30° to the horizontal.

(i) When the angle of 30° is **below** the horizontal (see Fig. 1), the ring is in limiting equilibrium. Show that the coefficient of friction between the ring and the rod is 0.666, correct to 3 significant figures. [5]

(ii) When the angle of 30° is **above** the horizontal (see Fig. 2), the ring is moving with acceleration a m s^{-2}. Find the value of a. [4]

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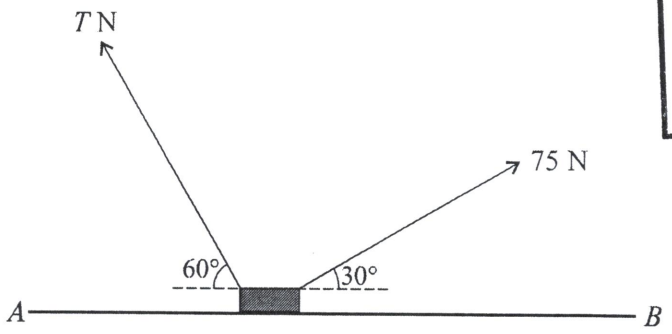

Two light strings are attached to a block of mass 20 kg. The block is in equilibrium on a horizontal surface AB with the strings taut. The strings make angles of 60° and 30° with the horizontal, on either side of the block, and the tensions in the strings are T N and 75 N respectively (see diagram).

(i) Given that the surface is smooth, find the value of T and the magnitude of the contact force acting on the block. [5]

(ii) It is given instead that the surface is rough and that the block is on the point of slipping. The frictional force on the block has magnitude 25 N and acts towards A. Find the coefficient of friction between the block and the surface. [6]

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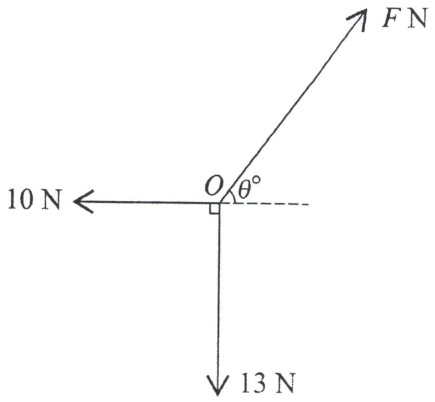

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Three horizontal forces of magnitudes FN, 13 N and 10 N act at a fixed point O and are in equilibrium. The directions of the forces are as shown in the diagram. Find, in either order, the value of θ and the value of F. [5]

J-8-3

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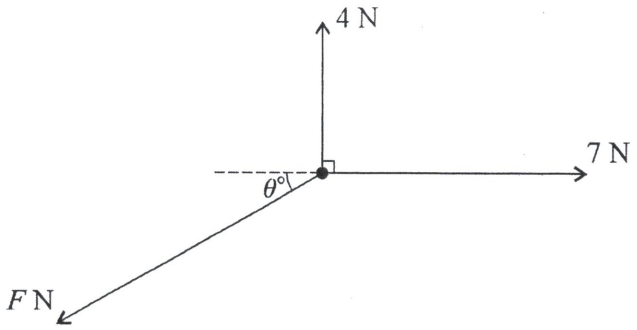

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A particle is in equilibrium on a smooth horizontal table when acted on by the three horizontal forces shown in the diagram.

N-7-3

(i) Find the values of F and θ. [4]

(ii) The force of magnitude 7 N is now removed. State the magnitude and direction of the resultant of the remaining two forces. [2]

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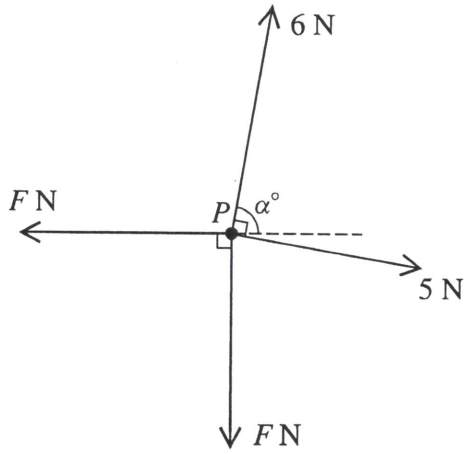

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A particle P is in equilibrium on a smooth horizontal table under the action of four horizontal forces of magnitudes 6 N, 5 N, F N and F N acting in the directions shown. Find the values of α and F. [6]

XII-SB-18 C

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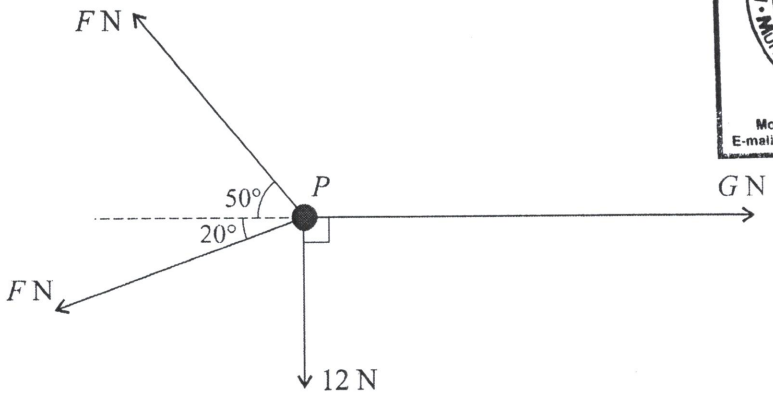

A particle P is in equilibrium on a smooth horizontal table under the action of horizontal forces of magnitudes FN, FN, GN and 12 N acting in the directions shown. Find the values of F and G. [6]

XII-SB-13

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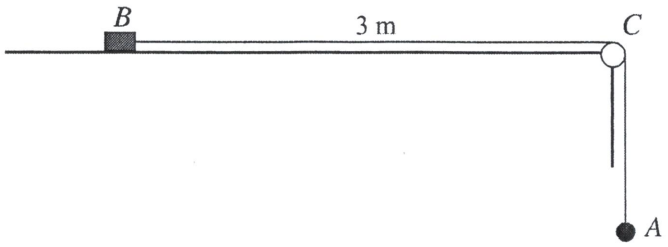

A block B of mass 0.6 kg and a particle A of mass 0.4 kg are attached to opposite ends of a light inextensible string. The block is held at rest on a rough horizontal table, and the coefficient of friction between the block and the table is 0.5. The string passes over a small smooth pulley C at the edge of the table and A hangs in equilibrium vertically below C. The part of the string between B and C is horizontal and the distance BC is 3 m (see diagram). B is released and the system starts to move.

(i) Find the acceleration of B and the tension in the string. [6]

(ii) Find the time taken for B to reach the pulley. [2]

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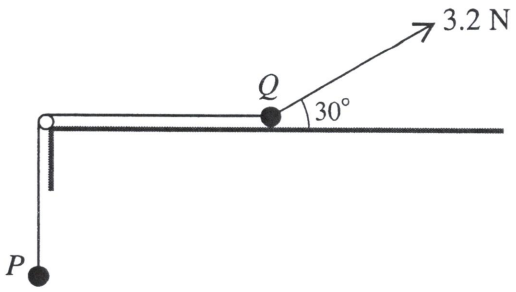

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Particles P and Q, of masses 0.2 kg and 0.5 kg respectively, are connected by a light inextensible string. The string passes over a smooth pulley at the edge of a rough horizontal table. P hangs freely and Q is in contact with the table. A force of magnitude 3.2 N acts on Q, upwards and away from the pulley, at an angle of 30° to the horizontal (see diagram). N-10-41-7

(i) The system is in limiting equilibrium with P about to move upwards. Find the coefficient of friction between Q and the table. [6]

The force of magnitude 3.2 N is now removed and P starts to move downwards.

(ii) Find the acceleration of the particles and the tension in the string. [4]

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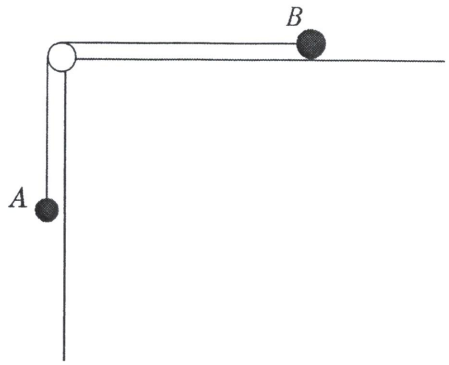

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Particles A and B, of masses 0.2 kg and 0.3 kg respectively, are connected by a light inextensible string. The string passes over a smooth pulley at the edge of a rough horizontal table. Particle A hangs freely and particle B is in contact with the table (see diagram).

(i) The system is in limiting equilibrium with the string taut and A about to move downwards. Find the coefficient of friction between B and the table. [4]

A force now acts on particle B. This force has a vertical component of 1.8 N upwards and a horizontal component of XN directed away from the pulley.

(ii) The system is now in limiting equilibrium with the string taut and A about to move **upwards**. Find X. [3]

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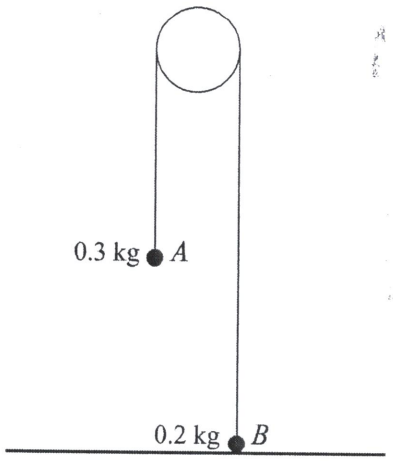

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Two particles A and B, of masses 0.3 kg and 0.2 kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. Particle B is held on the horizontal floor and particle A hangs in equilibrium. Particle B is released and each particle starts to move vertically with constant acceleration of magnitude $a\,\text{m s}^{-2}$.

(i) Find the value of a. [4]

Particle A hits the floor 1.2 s after it starts to move, and does not rebound upwards.

(ii) Show that A hits the floor with a speed of $2.4\,\text{m s}^{-1}$. [1]

(iii) Find the gain in gravitational potential energy by B, from leaving the floor until reaching its greatest height. [5]

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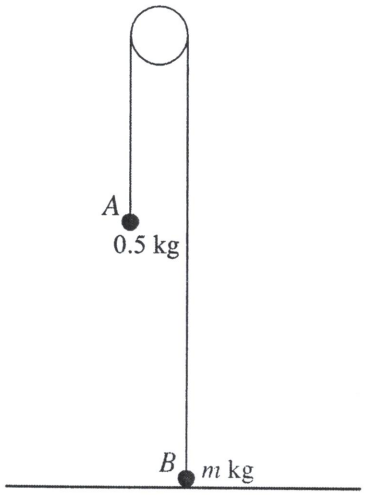

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Particles A and B, of masses 0.5 kg and m kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. Particle B is held at rest on the horizontal floor and particle A hangs in equilibrium (see diagram). B is released and each particle starts to move vertically. A hits the floor 2 s after B is released. The speed of each particle when A hits the floor is 5 m s^{-1}.

N-8-5

(i) For the motion while A is moving downwards, find

(a) the acceleration of A, [2]

(b) the tension in the string. [3]

(ii) Find the value of m. [3]

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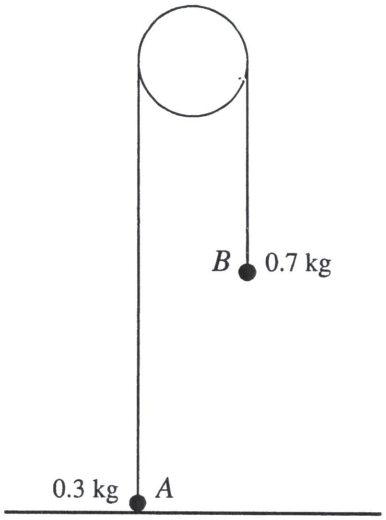

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Particles A and B, of masses 0.3 kg and 0.7 kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. Particle A is held on the horizontal floor and particle B hangs in equilibrium. Particle A is released and both particles start to move vertically.

N-9-42-6

(i) Find the acceleration of the particles. [3]

The speed of the particles immediately before B hits the floor is $1.6\,\text{m s}^{-1}$. Given that B does not rebound upwards, find

(ii) the maximum height above the floor reached by A, [3]

(iii) the time taken by A, from leaving the floor, to reach this maximum height. [3]

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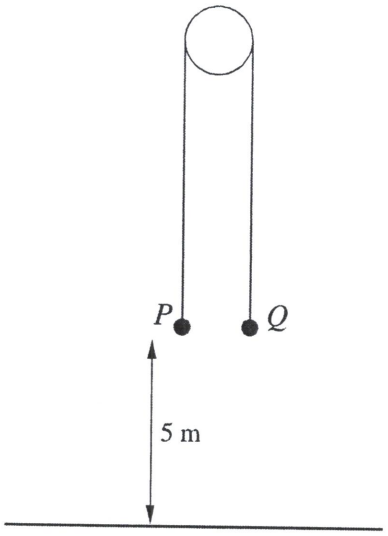

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Particles P and Q, of masses 0.55 kg and 0.45 kg respectively, are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. The particles are held at rest with the string taut and its straight parts vertical. Both particles are at a height of 5 m above the ground (see diagram). The system is released.

N-9-41-6

(i) Find the acceleration with which P starts to move. [3]

The string breaks after 2 s and in the subsequent motion P and Q move vertically under gravity.

(ii) At the instant that the string breaks, find

(a) the height above the ground of P and of Q, [2]

(b) the speed of the particles. [1]

(iii) Show that Q reaches the ground 0.8 s later than P. [4]

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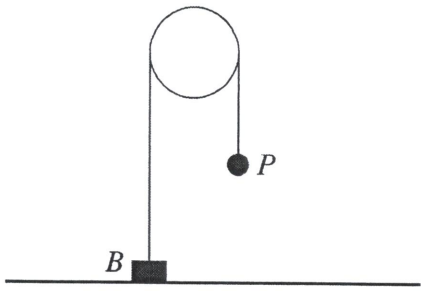

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A block B of mass 5 kg is attached to one end of a light inextensible string. A particle P of mass 4 kg is attached to other end of the string. The string passes over a smooth pulley. The system is in equilibrium with the string taut and its straight parts vertical. B is at rest on the ground (see diagram). State the tension in the string and find the force exerted on B by the ground. [3]

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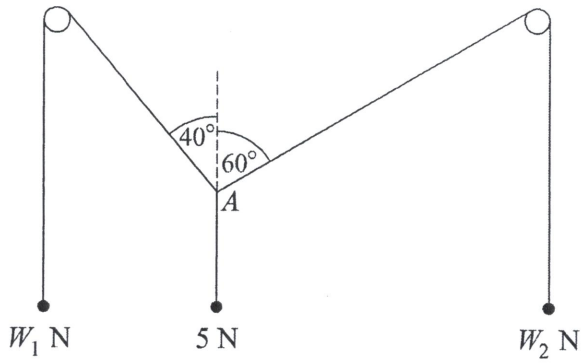

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Each of three light strings has a particle attached to one of its ends. The other ends of the strings are tied together at a point A. The strings are in equilibrium with two of them passing over fixed smooth horizontal pegs, and with the particles hanging freely. The weights of the particles, and the angles between the sloping parts of the strings and the vertical, are as shown in the diagram. Find the values of W_1 and W_2. [6]

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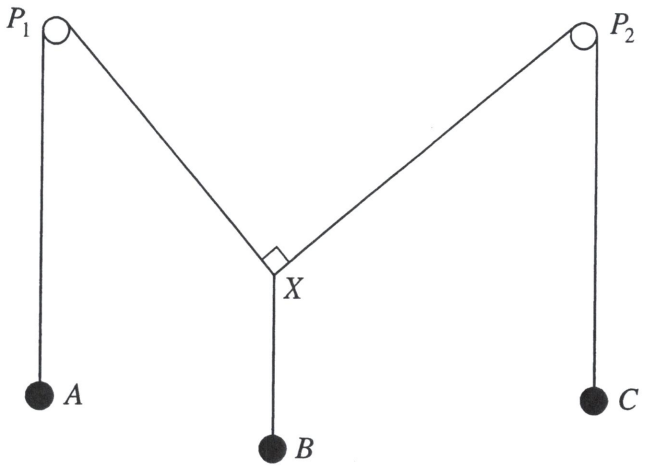

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The diagram shows three particles A, B and C hanging freely in equilibrium, each being attached to the end of a string. The other ends of the three strings are tied together and are at the point X. The strings carrying A and C pass over smooth fixed horizontal pegs P_1 and P_2 respectively. The weights of A, B and C are 5.5 N, 7.3 N and W N respectively, and the angle P_1XP_2 is a right angle. Find the angle AP_1X and the value of W. N-10-41 [5]

XII-SB-1.1