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Cambridge International AS & A Level

MATHEMATICS (9709) P4

TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS

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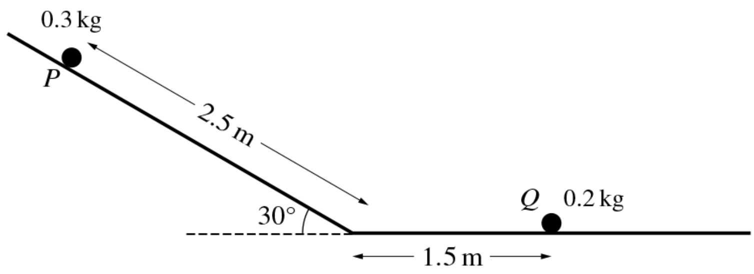
Chapter 4

Newton's laws of motion

136. 9709_s20_qp_41 Q: 7



A particle P of mass 0.3 kg, lying on a smooth plane inclined at 30° to the horizontal, is released from rest. P slides down the plane for a distance of 2.5 m and then reaches a horizontal plane. There is no change in speed when P reaches the horizontal plane. A particle Q of mass 0.2 kg lies at rest on the horizontal plane 1.5 m from the end of the inclined plane (see diagram). P collides directly with Q.

(a) It is given that the horizontal plane is smooth and that, after the collision, P continues moving in the same direction, with speed $2\,\mathrm{m\,s^{-1}}$.

Find the speed of Q after the collision. [5]

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(b) It is given instead that the horizontal plane is rough and that when P and Q collide, they coalesce and move with speed $1.2\,\text{m}\,\text{s}^{-1}$.

Find the coefficient of friction between P and the horizontal plane. [5]

137. 9709_s20_qp_43 Q: 2

A minibus of mass 4000 kg is travelling along a straight horizontal road. The resistance to motion is 900 N.

(a) Find the driving force when the acceleration of the minibus is $0.5\ \mathrm{m\,s^{-2}}$. [2]

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(b) Find the power required for the minibus to maintain a constant speed of $25\ \mathrm{m\,s^{-1}}$. [2]

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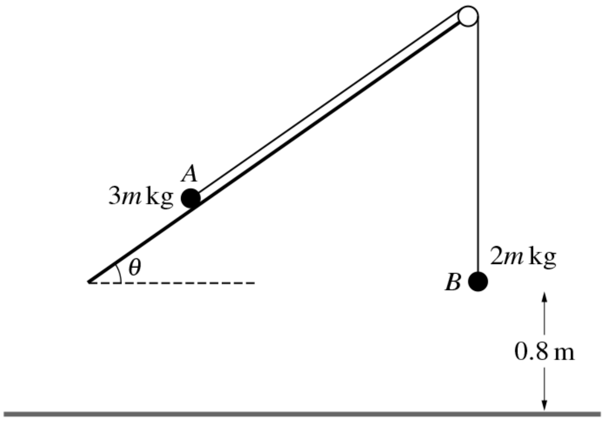
138. 9709_s20_qp_43 Q: 7



Two particles A and B, of masses $3m$ kg and $2m$ kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a plane. The plane is inclined at an angle θ to the horizontal. A lies on the plane and B hangs vertically, 0.8 m above the floor, which is horizontal. The string between A and the pulley is parallel to a line of greatest slope of the plane (see diagram). Initially A and B are at rest.

(a) Given that the plane is smooth, find the value of θ for which A remains at rest. [3]

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It is given instead that the plane is rough, $\theta = 30°$ and the acceleration of A up the plane is 0.1 m s^{-2}.

(b) Show that the coefficient of friction between A and the plane is $\frac{1}{10}\sqrt{3}$. [5]

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(c) When B reaches the floor it comes to rest.

Find the length of time after B reaches the floor for which A is moving up the plane. [You may assume that A does not reach the pulley.] [4]

139. 9709_W20_qp_41 Q: 2

A car of mass 1400 kg is moving along a straight horizontal road against a resistance of magnitude 350 N.

(a) Find, in kW, the rate at which the engine of the car is working when it is travelling at a constant speed of $20\,\mathrm{m\,s^{-1}}$. [2]

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(b) Find the acceleration of the car when its speed is $20\,\mathrm{m\,s^{-1}}$ and the engine is working at 15 kW. [3]

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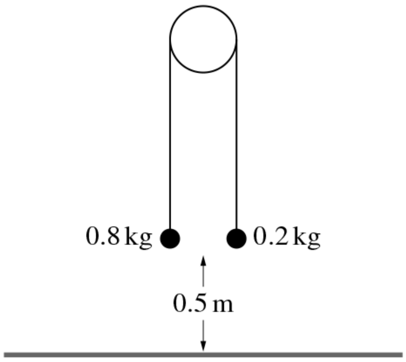
140. 9709_W20_qp_41 Q: 5



Two particles of masses 0.8 kg and 0.2 kg are connected by a light inextensible string that passes over a fixed smooth pulley. The system is released from rest with both particles 0.5 m above a horizontal floor (see diagram). In the subsequent motion the 0.2 kg particle does not reach the pulley.

(a) Show that the magnitude of the acceleration of the particles is $6 \mathrm{~m} \mathrm{~s}^{-2}$ and find the tension in the string. [4]

(b) When the 0.8 kg particle reaches the floor it comes to rest.

Find the greatest height of the 0.2 kg particle above the floor. [3]

141. 9709_W20_qp_42 Q: 6

A block of mass 5 kg is placed on a plane inclined at 30° to the horizontal. The coefficient of friction between the block and the plane is μ.

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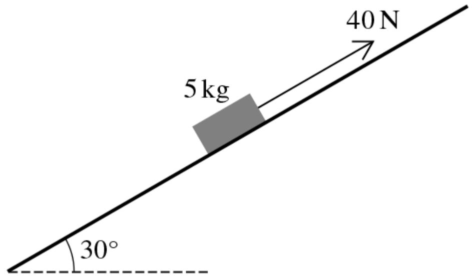

Fig. 6.1

When a force of magnitude 40 N is applied to the block, acting up the plane parallel to a line of greatest slope, the block begins to slide up the plane (see Fig. 6.1).

Show that $\mu < \frac{1}{5}\sqrt{3}$. [4]

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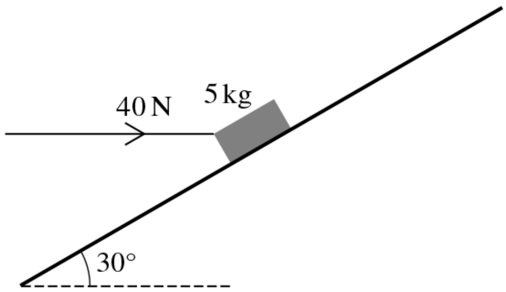
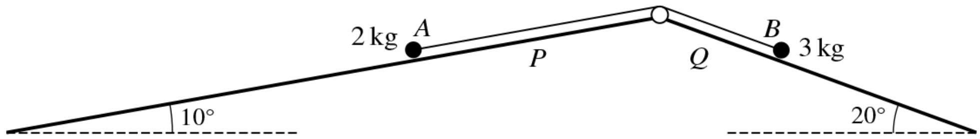


Fig. 6.2

When a force of magnitude 40 N is applied horizontally, in a vertical plane containing a line of greatest slope, the block does not move (see Fig. 6.2).

Show that, correct to 3 decimal places, the least possible value of μ is 0.152. [4]

142. 9709_W20_qp_43 Q: 7



As shown in the diagram, particles A and B of masses 2 kg and 3 kg respectively are attached to the ends of a light inextensible string. The string passes over a small fixed smooth pulley which is attached to the top of two inclined planes. Particle A is on plane P, which is inclined at an angle of 10° to the horizontal. Particle B is on plane Q, which is inclined at an angle of 20° to the horizontal. The string is taut, and the two parts of the string are parallel to lines of greatest slope of their respective planes.

(a) It is given that plane P is smooth, plane Q is rough, and the particles are in limiting equilibrium.

Find the coefficient of friction between particle B and plane Q. [5]

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(b) It is given instead that both planes are smooth and that the particles are released from rest at the same horizontal level.

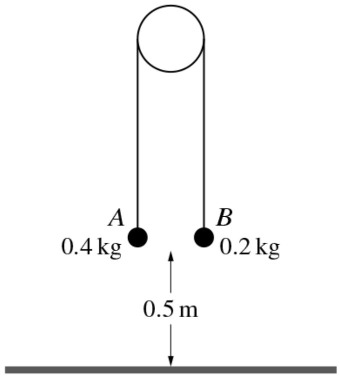
Find the time taken until the difference in the vertical height of the particles is 1 m. [You should assume that this occurs before A reaches the pulley or B reaches the bottom of plane Q.] [6]

143. 9709_s19_qp_42 Q: 4

A constant resistance to motion of magnitude 350 N acts on a car of mass 1250 kg. The engine of the car exerts a constant driving force of 1200 N. The car travels along a road inclined at an angle of θ to the horizontal, where $\sin\theta = 0.05$. Find the speed of the car when it has moved 100 m from rest in each of the following cases.

- The car is moving up the hill.
- The car is moving down the hill. [7]

144. 9709_s19_qp_42 Q: 5



Two particles A and B, of masses 0.4 kg and 0.2 kg respectively, are connected by a light inextensible string which passes over a fixed smooth pulley. Both A and B are 0.5 m above the ground. The particles hang vertically (see diagram). The particles are released from rest. In the subsequent motion B does not reach the pulley and A remains at rest after reaching the ground.

(i) For the motion before A reaches the ground, show that the magnitude of the acceleration of each particle is $\frac{10}{3}\,\text{m}\,\text{s}^{-2}$ and find the tension in the string. [4]

(ii) Find the maximum height of B above the ground. [4]

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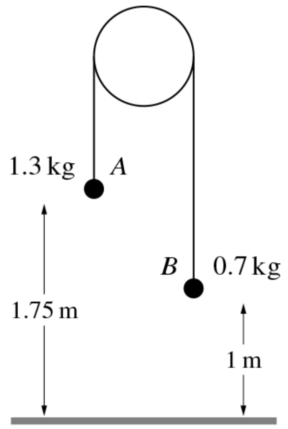
145. 9709_s19_qp_43 Q: 4



Two particles A and B, of masses 1.3 kg and 0.7 kg respectively, are connected by a light inextensible string which passes over a smooth fixed pulley. Particle A is 1.75 m above the floor and particle B is 1 m above the floor (see diagram). The system is released from rest with the string taut, and the particles move vertically. When the particles are at the same height the string breaks.

(i) Show that, before the string breaks, the magnitude of the acceleration of each particle is $3\,\mathrm{m\,s^{-2}}$ and find the tension in the string. [4]

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(ii) Find the difference in the times that it takes the particles to hit the ground. [6]

146. 9709_w19_qp_41 Q: 3

A block of mass 3 kg is at rest on a rough plane inclined at 60° to the horizontal. A force of magnitude 15 N acting up a line of greatest slope of the plane is just sufficient to prevent the block from sliding down the plane.

(i) Find the coefficient of friction between the block and the plane. [5]

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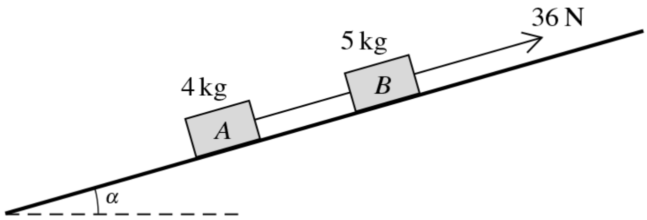
The force of magnitude 15 N is now replaced by a force of magnitude X N acting up the line of greatest slope.

(ii) Find the greatest value of X for which the block does not move. [2]

147. 9709_w19_qp_41 Q: 4



Two blocks A and B of masses 4 kg and 5 kg respectively are joined by a light inextensible string. The blocks rest on a smooth plane inclined at an angle α to the horizontal, where $\tan\alpha = \frac{7}{24}$. The string is parallel to a line of greatest slope of the plane with B above A. A force of magnitude 36 N acts on B, parallel to a line of greatest slope of the plane (see diagram).

(i) Find the acceleration of the blocks and the tension in the string. [5]

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(ii) At a particular instant, the speed of the blocks is $1\,\text{m}\,\text{s}^{-1}$. Find the time, after this instant, that it takes for the blocks to travel 0.65 m. [2]

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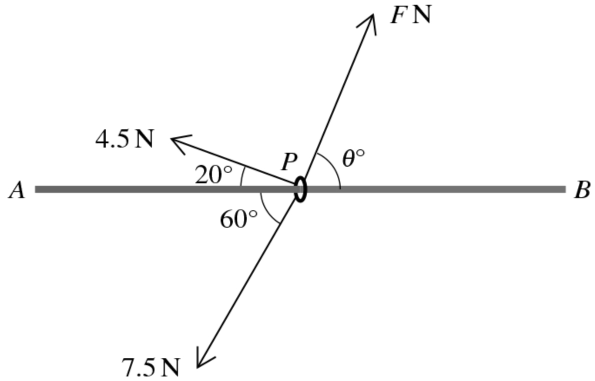
148. 9709_w19_qp_41 Q: 5



A small ring P is threaded on a fixed smooth horizontal rod AB. Three horizontal forces of magnitudes 4.5 N, 7.5 N and F N act on P (see diagram).

(i) Given that these three forces are in equilibrium, find the values of F and θ. [6]

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(ii) It is given instead that the values of F and θ are 9.5 and 30 respectively, and the acceleration of the ring is $1.5\,\mathrm{m\,s^{-2}}$. Find the mass of the ring. [2]

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149. 9709_w19_qp_41 Q: 6

A particle of mass 0.4 kg is released from rest at a height of 1.8 m above the surface of the water in a tank. There is no instantaneous change of speed when the particle enters the water. The water exerts an upward force of 5.6 N on the particle when it is in the water.

(i) Find the velocity of the particle at the instant when it reaches the surface of the water. [2]

(ii) Find the time that it takes from the instant when the particle enters the water until it comes to instantaneous rest in the water. You may assume that the tank is deep enough so that the particle does not reach the bottom of the tank. [4]

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(iii) Sketch a velocity-time graph for the motion of the particle from the instant at which it is released until it comes to instantaneous rest in the water. [3]

150. 9709_w19_qp_42 Q: 6

A block of mass 3 kg is initially at rest on a rough horizontal plane. A force of magnitude 6 N is applied to the block at an angle of θ above the horizontal, where $\cos\theta = \frac{24}{25}$. The force is applied for a period of 5 s, during which time the block moves a distance of 4.5 m.

(i) Find the magnitude of the frictional force on the block. [4]

(ii) Show that the coefficient of friction between the block and the plane is 0.165, correct to 3 significant figures. [3]

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(iii) When the block has moved a distance of 4.5 m, the force of magnitude 6 N is removed and the block then decelerates to rest. Find the total time for which the block is in motion. [4]

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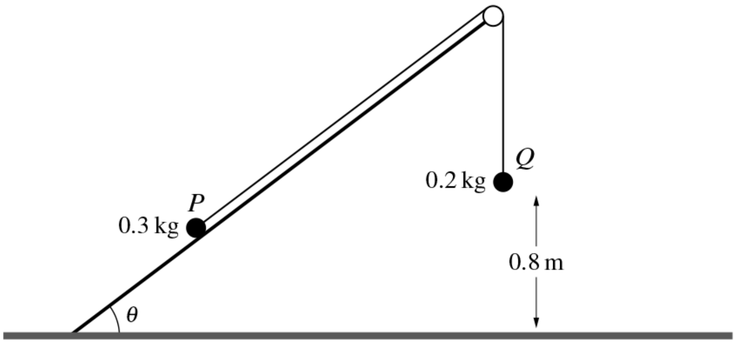
151. 9709_w19_qp_42 Q: 7



Two particles P and Q, of masses 0.3 kg and 0.2 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a smooth plane. The plane is inclined at an angle θ to the horizontal, where $\sin\theta = \frac{3}{5}$. P lies on the plane and Q hangs vertically below the pulley at a height of 0.8 m above the floor (see diagram). The string between P and the pulley is parallel to a line of greatest slope of the plane. P is released from rest and Q moves vertically downwards.

(i) Find the tension in the string and the magnitude of the acceleration of the particles. [5]

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Q hits the floor and does not bounce. It is given that P does not reach the pulley in the subsequent motion.

(ii) Find the time, from the instant at which P is released, for Q to reach the floor. [2]

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(iii) When Q hits the floor the string becomes slack. Find the time, from the instant at which P is released, for the string to become taut again. [4]

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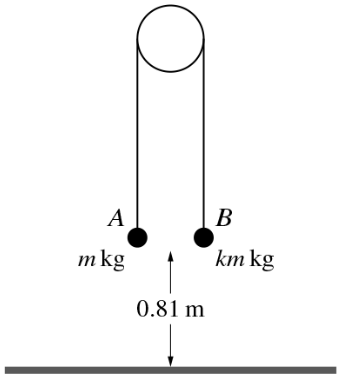
152. 9709_w19_qp_43 Q: 7



Two particles A and B have masses m kg and km kg respectively, where $k > 1$. The particles are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley and the particles hang vertically below it. Both particles are at a height of 0.81 m above horizontal ground (see diagram). The system is released from rest and particle B reaches the ground 0.9 s later. The particle A does not reach the pulley in its subsequent motion.

(i) Find the value of k and show that the tension in the string before B reaches the ground is equal to $12m$ N. [7]

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At the instant when B reaches the ground, the string breaks.

(ii) Show that the speed of A when it reaches the ground is $5.97\ \text{m s}^{-1}$, correct to 3 significant figures, and find the time taken, after the string breaks, for A to reach the ground. [4]

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(iii) Sketch a velocity-time graph for the motion of particle A from the instant when the system is released until A reaches the ground. [2]

153. 9709_m18_qp_42 Q: 1

Two particles A and B, of masses 0.8 kg and 0.2 kg respectively, are connected by a light inextensible string that passes over a fixed smooth pulley. The particles hang vertically. The system is released from rest. Show that the acceleration of A has magnitude $6\,\mathrm{m\,s^{-2}}$ and find the tension in the string. [4]

154. 9709_m18_qp_42 Q: 4

A particle of mass 12 kg is on a rough plane inclined at an angle of 25° to the horizontal. A force of magnitude P N acts on the particle. This force is horizontal and the particle is on the point of moving up a line of greatest slope of the plane. The coefficient of friction between the particle and the plane is 0.8. Find the value of P. [6]

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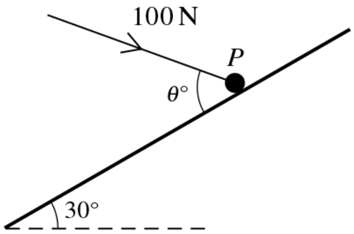
155. 9709_s18_qp_41 Q: 3

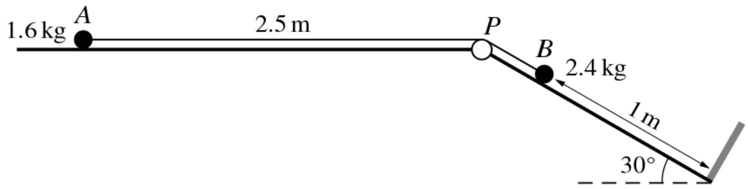


A particle P of mass 8 kg is on a smooth plane inclined at an angle of 30° to the horizontal. A force of magnitude 100 N, making an angle of $\theta°$ with a line of greatest slope and lying in the vertical plane containing the line of greatest slope, acts on P (see diagram).

(i) Given that P is in equilibrium, show that $\theta = 66.4$, correct to 1 decimal place, and find the normal reaction between the plane and P. [4]

(ii) Given instead that $\theta = 30$, find the acceleration of P. [2]

156. 9709_s18_qp_42 Q: 7



As shown in the diagram, a particle A of mass 1.6 kg lies on a horizontal plane and a particle B of mass 2.4 kg lies on a plane inclined at an angle of 30° to the horizontal. The particles are connected by a light inextensible string which passes over a small smooth pulley P fixed at the top of the inclined plane. The distance AP is 2.5 m and the distance of B from the bottom of the inclined plane is 1 m. There is a barrier at the bottom of the inclined plane preventing any further motion of B. The part BP of the string is parallel to a line of greatest slope of the inclined plane. The particles are released from rest with both parts of the string taut.

(i) Given that both planes are smooth, find the acceleration of A and the tension in the string. [5]

(ii) It is given instead that the horizontal plane is rough and that the coefficient of friction between A and the horizontal plane is 0.2. The inclined plane is smooth. Find the total distance travelled by A. [9]

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157. 9709_w18_qp_41 Q: 1

A particle of mass 0.2 kg moving in a straight line experiences a constant resistance force of 1.5 N. When the particle is moving at speed 2.5 m s^{-1}, a constant force of magnitude F N is applied to it in the direction in which it is moving. Given that the speed of the particle 5 seconds later is 4.5 m s^{-1}, find the value of F. [4]

158. 9709_w18_qp_41 Q: 4

Two particles A and B, of masses m kg and 0.3 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley and the particles hang freely below it. The system is released from rest, with both particles 0.8 m above horizontal ground. Particle A reaches the ground with a speed of $0.6\ \mathrm{m\,s^{-1}}$.

(i) Find the tension in the string during the motion before A reaches the ground. [4]

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(ii) Find the value of m. [2]

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159. 9709_w18_qp_41 Q: 6

A particle is projected from a point P with initial speed $u\,\mathrm{m\,s^{-1}}$ up a line of greatest slope PQR of a rough inclined plane. The distances PQ and QR are both equal to 0.8 m. The particle takes 0.6 s to travel from P to Q and 1 s to travel from Q to R.

(i) Show that the deceleration of the particle is $\frac{2}{3}\,\mathrm{m\,s^{-2}}$ and hence find u, giving your answer as an exact fraction. [6]

(ii) Given that the plane is inclined at 3° to the horizontal, find the value of the coefficient of friction between the particle and the plane. [4]

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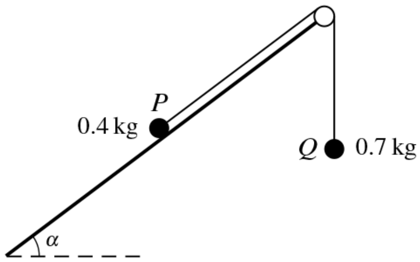
160. 9709_w18_qp_42 Q: 4



Two particles P and Q, of masses 0.4 kg and 0.7 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a rough plane. The coefficient of friction between P and the plane is 0.5. The plane is inclined at an angle α to the horizontal, where $\tan\alpha = \frac{3}{4}$. Particle P lies on the plane and particle Q hangs vertically. The string between P and the pulley is parallel to a line of greatest slope of the plane (see diagram). A force of magnitude X N, acting directly down the plane, is applied to P.

(i) Show that the greatest value of X for which P remains stationary is 6.2. [4]

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(ii) Given instead that $X = 0.8$, find the acceleration of P. [4]

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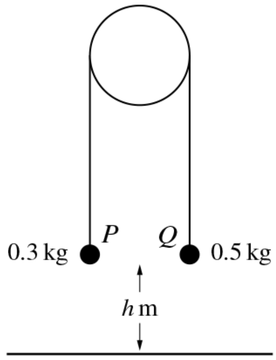
161. 9709_w18_qp_43 Q: 5



Two particles P and Q, of masses 0.3 kg and 0.5 kg respectively, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley with the particles hanging freely below it. Q is held at rest with the string taut at a height of h m above a horizontal floor (see diagram). Q is now released and both particles start to move. The pulley is sufficiently high so that P does not reach it at any stage. The time taken for Q to reach the floor is 0.6 s.

(i) Find the acceleration of Q before it reaches the floor and hence find the value of h. [6]

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Q remains at rest when it reaches the floor, and P continues to move upwards.

(ii) Find the velocity of P at the instant when Q reaches the floor and the total time taken from the instant at which Q is released until the string becomes taut again. [3]

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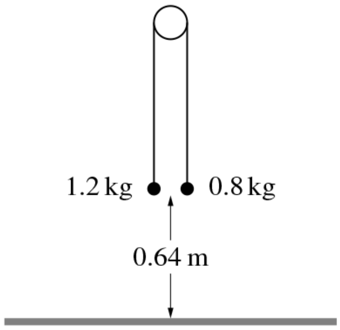
162. 9709_m17_qp_42 Q: 6



Two particles of masses 1.2 kg and 0.8 kg are connected by a light inextensible string that passes over a fixed smooth pulley. The particles hang vertically. The system is released from rest with both particles 0.64 m above the floor (see diagram). In the subsequent motion the 0.8 kg particle does not reach the pulley.

(i) Show that the acceleration of the particles is 2 m s^{-2} and find the tension in the string. [4]

(ii) Find the total distance travelled by the 0.8 kg particle during the first second after the particles are released. [8]

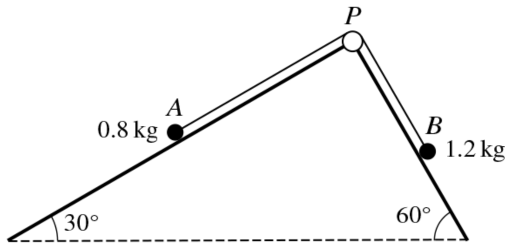
163. 9709_s17_qp_41 Q: 2

A particle of mass 0.8 kg is projected with a speed of $12\,\text{m}\,\text{s}^{-1}$ up a line of greatest slope of a rough plane inclined at an angle of $10°$ to the horizontal. The coefficient of friction between the particle and the plane is 0.4.

(i) Find the acceleration of the particle. [4]

(ii) Find the distance the particle moves up the plane before coming to rest. [2]

164. 9709_s17_qp_41 Q: 7



As shown in the diagram, a particle A of mass 0.8 kg lies on a plane inclined at an angle of 30° to the horizontal and a particle B of mass 1.2 kg lies on a plane inclined at an angle of 60° to the horizontal. The particles are connected by a light inextensible string which passes over a small smooth pulley P fixed at the top of the planes. The parts AP and BP of the string are parallel to lines of greatest slope of the respective planes. The particles are released from rest with both parts of the string taut.

(i) Given that both planes are smooth, find the acceleration of A and the tension in the string. [6]

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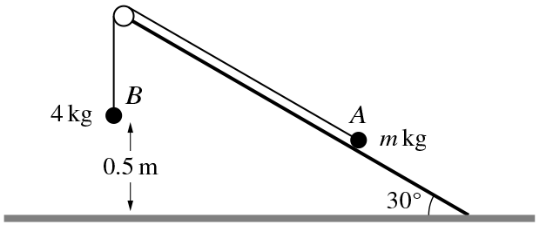
(ii) It is given instead that both planes are rough, with the same coefficient of friction, μ, for both particles. Find the value of μ for which the system is in limiting equilibrium. [6]

165. 9709_s17_qp_43 Q: 7



Two particles A and B of masses m kg and 4 kg respectively are connected by a light inextensible string that passes over a fixed smooth pulley. Particle A is on a rough fixed slope which is at an angle of 30° to the horizontal ground. Particle B hangs vertically below the pulley and is 0.5 m above the ground (see diagram). The coefficient of friction between the slope and particle A is 0.2.

(i) In the case where the system is in equilibrium with particle A on the point of moving directly up the slope, show that $m = 5.94$, correct to 3 significant figures. [6]

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(ii) In the case where $m = 3$, the system is released from rest with the string taut. Find the total distance travelled by A before coming to instantaneous rest. You may assume that A does not reach the pulley. [8]

166. 9709_w17_qp_41 Q: 1

A block of mass 3 kg is initially at rest on a smooth horizontal floor. A force of 12 N, acting at an angle of 25° above the horizontal, is applied to the block. Find the distance travelled by the block in the first 5 seconds of its motion. [4]

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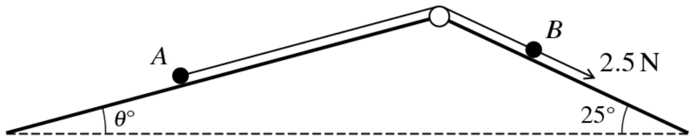
167. 9709_w17_qp_41 Q: 7



Two particles A and B of masses 0.9 kg and 0.4 kg respectively are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the top of two inclined planes. The particles are initially at rest with A on a smooth plane inclined at angle $\theta°$ to the horizontal and B on a plane inclined at angle 25° to the horizontal. The string is taut and the particles can move on lines of greatest slope of the two planes. A force of magnitude 2.5 N is applied to B acting down the plane (see diagram).

(i) For the case where $\theta = 15$ and the plane on which B rests is smooth, find the acceleration of B. [5]

(ii) For a different value of θ, the plane on which B rests is rough with coefficient of friction between the plane and B of 0.8. The system is in limiting equilibrium with B on the point of moving in the direction of the 2.5 N force. Find the value of θ. [5]

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168. 9709_w17_qp_42 Q: 1

A particle of mass 0.2 kg is resting in equilibrium on a rough plane inclined at 20° to the horizontal.

(i) Show that the friction force acting on the particle is 0.684 N, correct to 3 significant figures. [1]

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The coefficient of friction between the particle and the plane is 0.6. A force of magnitude 0.9 N is applied to the particle down a line of greatest slope of the plane. The particle accelerates down the plane.

(ii) Find this acceleration. [4]

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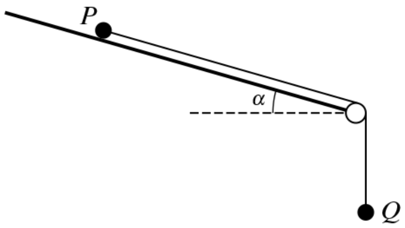
169. 9709_w17_qp_42 Q: 6



Two particles P and Q, each of mass m kg, are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the edge of a rough plane. The plane is inclined at an angle α to the horizontal, where $\tan \alpha = \frac{7}{24}$. Particle P rests on the plane and particle Q hangs vertically, as shown in the diagram. The string between P and the pulley is parallel to a line of greatest slope of the plane. The system is in limiting equilibrium.

(i) Show that the coefficient of friction between P and the plane is $\frac{4}{3}$. [5]

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A force of magnitude 10 N is applied to P, acting up a line of greatest slope of the plane, and P accelerates at $2.5\,\mathrm{m\,s^{-2}}$.

(ii) Find the value of m. [5]

170. 9709_w17_qp_43 Q: 3

A particle is released from rest and slides down a line of greatest slope of a rough plane which is inclined at 25° to the horizontal. The coefficient of friction between the particle and the plane is 0.4.

(i) Find the acceleration of the particle. [4]

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(ii) Find the distance travelled by the particle in the first 3 s after it is released. [2]

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171. 9709_m16_qp_42 Q: 4

A particle P of mass 0.8 kg is placed on a rough horizontal table. The coefficient of friction between P and the table is μ. A force of magnitude 5 N, acting upwards at an angle α above the horizontal, where $\tan\alpha = \frac{3}{4}$, is applied to P. The particle is on the point of sliding on the table.

(i) Find the value of μ. [4]

(ii) The magnitude of the force acting on P is increased to 10 N, with the direction of the force remaining the same. Find the acceleration of P. [3]

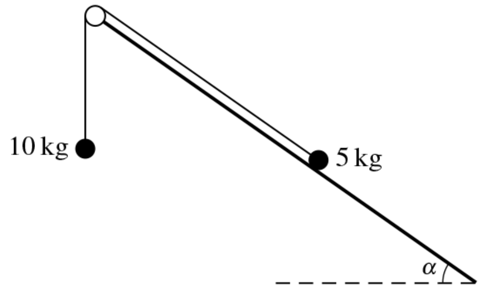
172. 9709_m16_qp_42 Q: 6

Two particles A and B, of masses 0.8 kg and 0.2 kg respectively, are connected by a light inextensible string. Particle A is placed on a horizontal surface. The string passes over a small smooth pulley P fixed at the edge of the surface, and B hangs freely. The horizontal section of the string, AP, is of length 2.5 m. The particles are released from rest with both sections of the string taut.

(i) Given that the surface is smooth, find the time taken for A to reach the pulley. [5]

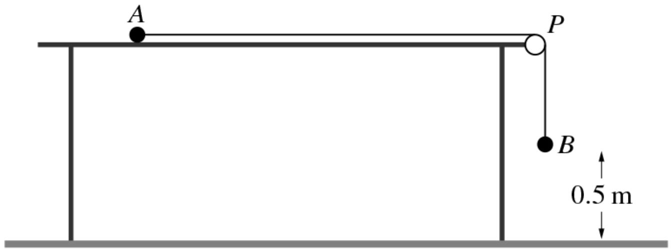
(ii) Given instead that the surface is rough and the coefficient of friction between A and the surface is 0.1, find the speed of A immediately before it reaches the pulley. [5]

173. 9709_s16_qp_41 Q: 5



Two particles of masses 5 kg and 10 kg are connected by a light inextensible string that passes over a fixed smooth pulley. The 5 kg particle is on a rough fixed slope which is at an angle of α to the horizontal, where $\tan\alpha = \frac{3}{4}$. The 10 kg particle hangs below the pulley (see diagram). The coefficient of friction between the slope and the 5 kg particle is $\frac{1}{2}$. The particles are released from rest. Find the acceleration of the particles and the tension in the string. [7]

174. 9709_s16_qp_42 Q: 7



A particle A of mass 1.6 kg rests on a horizontal table and is attached to one end of a light inextensible string. The string passes over a small smooth pulley P fixed at the edge of the table. The other end of the string is attached to a particle B of mass 2.4 kg which hangs freely below the pulley. The system is released from rest with the string taut and with B at a height of 0.5 m above the ground, as shown in the diagram. In the subsequent motion A does not reach P before B reaches the ground.

(i) Given that the table is smooth, find the time taken by B to reach the ground. [5]

(ii) Given instead that the table is rough and that the coefficient of friction between A and the table is $\frac{3}{8}$, find the total distance travelled by A. You may assume that A does not reach the pulley. [7]

175. 9709_w16_qp_41 Q: 2

A particle of mass 0.1 kg is released from rest on a rough plane inclined at 20° to the horizontal. It is given that, 5 seconds after release, the particle has a speed of $2\,\mathrm{m\,s^{-1}}$.

(i) Find the acceleration of the particle and hence show that the magnitude of the frictional force acting on the particle is 0.302 N, correct to 3 significant figures. [3]

(ii) Find the coefficient of friction between the particle and the plane. [2]

176. 9709_w16_qp_42 Q: 1

A particle of mass 2 kg is initially at rest on a rough horizontal plane. A force of magnitude 10 N is applied to the particle at 15° above the horizontal. It is given that 10 s after the force is applied, the particle has a speed of $3.5\ \mathrm{m\,s^{-1}}$.

(i) Show that the magnitude of the frictional force is 8.96 N, correct to 3 significant figures. [3]

(ii) Find the coefficient of friction between the particle and the plane. [3]

177. 9709_w16_qp_43 Q: 3

Particles P and Q, of masses 7 kg and 3 kg respectively, are attached to the two ends of a light inextensible string. The string passes over two small smooth pulleys attached to the two ends of a horizontal table. The two particles hang vertically below the two pulleys. The two particles are both initially at rest, 0.5 m below the level of the table, and 0.4 m above the horizontal floor (see diagram).

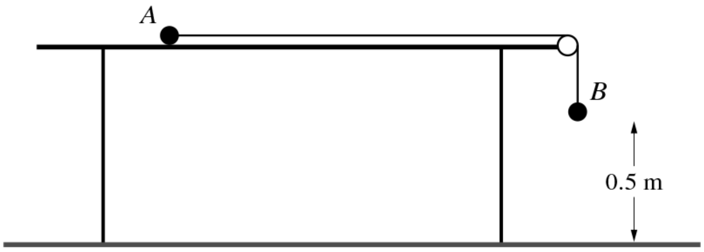
(i) Find the acceleration of the particles and the speed of P immediately before it reaches the floor. [4]

(ii) Determine whether Q comes to instantaneous rest before it reaches the pulley directly above it. [2]

178. 9709_s15_qp_41 Q: 3

A block of weight 6.1 N slides down a slope inclined at $\tan^{-1}(\frac{11}{60})$ to the horizontal. The coefficient of friction between the block and the slope is $\frac{1}{4}$. The block passes through a point A with speed $2\,\mathrm{m\,s^{-1}}$. Find how far the block moves from A before it comes to rest. [5]

179. 9709_s15_qp_41 Q: 7



Particles A and B, of masses 0.3 kg and 0.7 kg respectively, are attached to the ends of a light inextensible string. Particle A is held at rest on a rough horizontal table with the string passing over a smooth pulley fixed at the edge of the table. The coefficient of friction between A and the table is 0.2. Particle B hangs vertically below the pulley at a height of 0.5 m above the floor (see diagram). The system is released from rest and 0.25 s later the string breaks. A does not reach the pulley in the subsequent motion. Find

(i) the speed of B immediately before it hits the floor, [9]

(ii) the total distance travelled by A. [3]

180. 9709_s15_qp_42 Q: 6

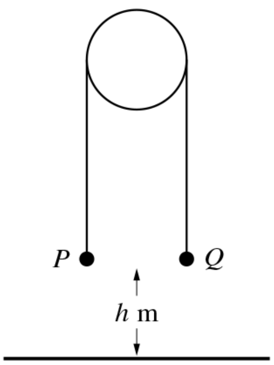


Fig. 1

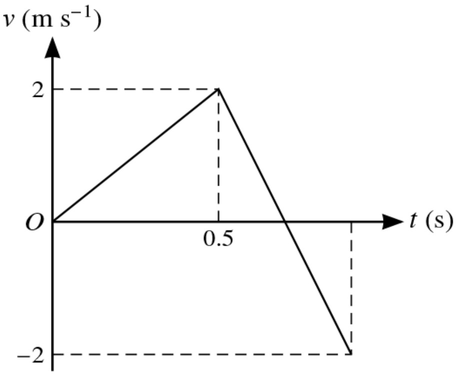


Fig. 2

Two particles P and Q have masses m kg and $(1 - m)$ kg respectively. The particles are attached to the ends of a light inextensible string which passes over a smooth fixed pulley. P is held at rest with the string taut and both straight parts of the string vertical. P and Q are each at a height of h m above horizontal ground (see Fig. 1). P is released and Q moves downwards. Subsequently Q hits the ground and comes to rest. Fig. 2 shows the velocity-time graph for P while Q is moving downwards or is at rest on the ground.

(i) Find the value of h. [2]

(ii) Find the value of m, and find also the tension in the string while Q is moving. [6]

(iii) The string is slack while Q is at rest on the ground. Find the total time from the instant that P is released until the string becomes taut again. [3]

181. 9709_s15_qp_43 Q: 6

A small box of mass 5 kg is pulled at a constant speed of $2.5\,\mathrm{m\,s^{-1}}$ down a line of greatest slope of a rough plane inclined at 10° to the horizontal. The pulling force has magnitude 20 N and acts downwards parallel to a line of greatest slope of the plane.

(i) Find the coefficient of friction between the box and the plane. [5]

The pulling force is removed while the box is moving at $2.5\,\mathrm{m\,s^{-1}}$.

(ii) Find the distance moved by the box after the instant at which the pulling force is removed. [4]

182. 9709_w15_qp_41 Q: 2

A particle of mass 0.5 kg starts from rest and slides down a line of greatest slope of a smooth plane. The plane is inclined at an angle of 30° to the horizontal.

(i) Find the time taken for the particle to reach a speed of $2.5\,\text{m}\,\text{s}^{-1}$. [3]

When the particle has travelled 3 m down the slope from its starting point, it reaches rough horizontal ground at the bottom of the slope. The frictional force acting on the particle is 1 N.

(ii) Find the distance that the particle travels along the ground before it comes to rest. [3]

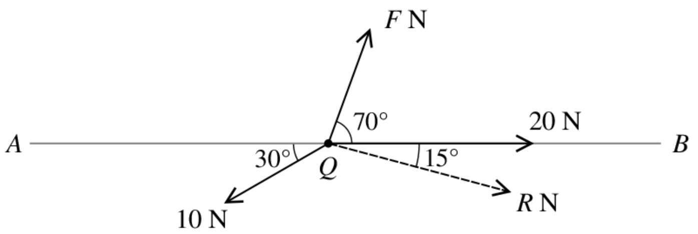
183. 9709_w15_qp_41 Q: 3

A lorry of mass 24 000 kg is travelling up a hill which is inclined at 3° to the horizontal. The power developed by the lorry's engine is constant, and there is a constant resistance to motion of 3200 N.

(i) When the speed of the lorry is $25\,\mathrm{m\,s^{-1}}$, its acceleration is $0.2\,\mathrm{m\,s^{-2}}$. Find the power developed by the lorry's engine. [4]

(ii) Find the steady speed at which the lorry moves up the hill if the power is 500 kW and the resistance remains 3200 N. [2]

184. 9709_w15_qp_41 Q: 5

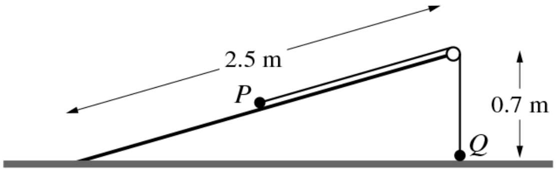


A small bead Q can move freely along a smooth horizontal straight wire AB of length 3 m. Three horizontal forces of magnitudes F N, 10 N and 20 N act on the bead in the directions shown in the diagram. The magnitude of the resultant of the three forces is R N in the direction shown in the diagram.

(i) Find the values of F and R. [5]

(ii) Initially the bead is at rest at A. It reaches B with a speed of 11.7 m s^{-1}. Find the mass of the bead. [3]

185. 9709_w15_qp_42 Q: 5



A smooth inclined plane of length 2.5 m is fixed with one end on the horizontal floor and the other end at a height of 0.7 m above the floor. Particles P and Q, of masses 0.5 kg and 0.1 kg respectively, are attached to the ends of a light inextensible string which passes over a small smooth pulley fixed at the top of the plane. Particle Q is held at rest on the floor vertically below the pulley. The string is taut and P is at rest on the plane (see diagram). Q is released and starts to move vertically upwards towards the pulley and P moves down the plane.

(i) Find the tension in the string and the magnitude of the acceleration of the particles before Q reaches the pulley. [5]

At the instant just before Q reaches the pulley the string breaks; P continues to move down the plane and reaches the floor with a speed of $2\,\text{m}\,\text{s}^{-1}$.

(ii) Find the length of the string. [3]

186. 9709_w15_qp_42 Q: 6

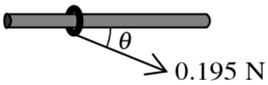


Fig. 1

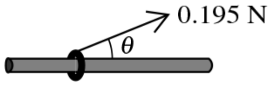


Fig. 2

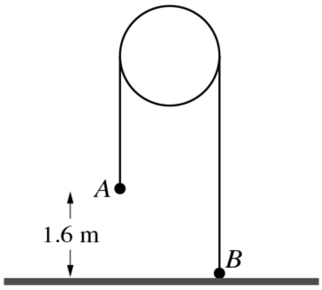
A small ring of mass 0.024 kg is threaded on a fixed rough horizontal rod. A light inextensible string is attached to the ring and the string is pulled with a force of magnitude 0.195 N at an angle of θ with the horizontal, where $\sin\theta = \frac{5}{13}$. When the angle θ is below the horizontal (see Fig. 1) the ring is in limiting equilibrium.

(i) Find the coefficient of friction between the ring and the rod. [6]

When the angle θ is above the horizontal (see Fig. 2) the ring moves.

(ii) Find the acceleration of the ring. [4]

187. 9709_w15_qp_43 Q: 4



Particles A and B, of masses 0.35 kg and 0.15 kg respectively, are attached to the ends of a light inextensible string which passes over a fixed smooth pulley. The system is at rest with B held on the horizontal floor, the string taut and its straight parts vertical. A is at a height of 1.6 m above the floor (see diagram). B is released and the system begins to move; B does not reach the pulley. Find

(i) the acceleration of the particles and the tension in the string before A reaches the floor, [4]

(ii) the greatest height above the floor reached by B. [3]