Cambridge International AS & A Level

MATHEMATICS (9709) P4

TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS

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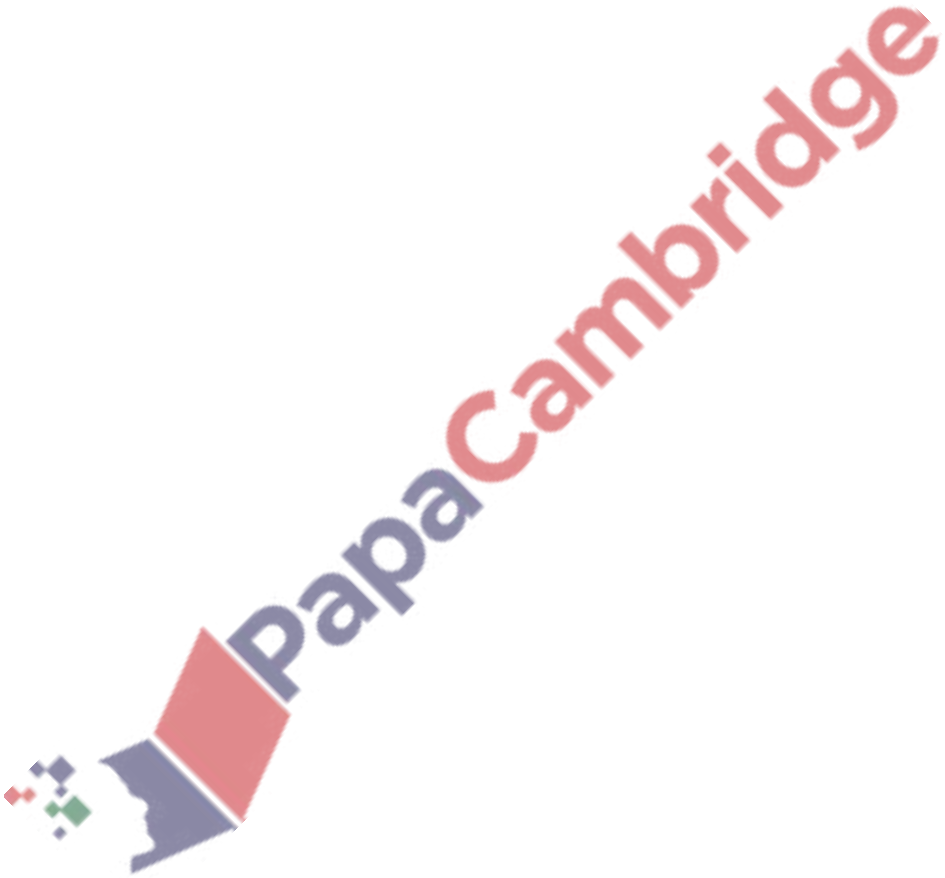
Chapter 5

Energy, work and power



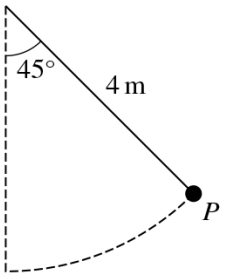
188. 9709_s20_qp_41 Q: 2

A car of mass 1800 kg is towing a trailer of mass 400 kg along a straight horizontal road. The car and trailer are connected by a light rigid tow-bar. The car is accelerating at 1.5 m s^{-2}. There are constant resistance forces of 250 N on the car and 100 N on the trailer.

(a) Find the tension in the tow-bar. [2]

(b) Find the power of the engine of the car at the instant when the speed is 20 m s^{-1}. [3]

189. 9709_s20_qp_41 Q: 5



A child of mass 35 kg is swinging on a rope. The child is modelled as a particle P and the rope is modelled as a light inextensible string of length 4 m. Initially P is held at an angle of 45° to the vertical (see diagram).

(a) Given that there is no resistance force, find the speed of P when it has travelled half way along the circular arc from its initial position to its lowest point. [4]

(b) It is given instead that there is a resistance force. The work done against the resistance force as P travels from its initial position to its lowest point is X J. The speed of P at its lowest point is $4\,\text{m}\,\text{s}^{-1}$.

Find X. [3]

190. 9709_s20_qp_42 Q: 4

Small smooth spheres A and B, of equal radii and of masses 4 kg and 2 kg respectively, lie on a smooth horizontal plane. Initially B is at rest and A is moving towards B with speed $10\,\text{m}\,\text{s}^{-1}$. After the spheres collide A continues to move in the same direction but with half the speed of B.

(a) Find the speed of B after the collision. [2]

A third small smooth sphere C, of mass 1 kg and with the same radius as A and B, is at rest on the plane. B now collides directly with C. After this collision B continues to move in the same direction but with one third the speed of C.

(b) Show that there is another collision between A and B. [3]

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(c) *A* and *B* coalesce during this collision.

Find the total loss of kinetic energy in the system due to the three collisions. [5]

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191. 9709_s20_qp_42 Q: 5

A car of mass 1250 kg is moving on a straight road.

(a) On a horizontal section of the road, the car has a constant speed of 32 m s^{-1} and there is a constant force of 750 N resisting the motion.

(i) Calculate, in kW, the power developed by the engine of the car. [2]

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(ii) Given that this power is suddenly decreased by 8 kW, find the instantaneous deceleration of the car. [3]

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(b) On a section of the road inclined at $\sin^{-1} 0.096$ to the horizontal, the resistance to the motion of the car is $(1000 + 8v)$ N when the speed of the car is v m s^{-1}. The car travels up this section of the road at constant speed with the engine working at 60 kW.

Find this constant speed. [5]

192. 9709_s20_qp_43 Q: 5

A block B of mass 4 kg is pushed up a line of greatest slope of a smooth plane inclined at 30° to the horizontal by a force applied to B, acting in the direction of motion of B. The block passes through points P and Q with speeds 12 m s^{-1} and 8 m s^{-1} respectively. P and Q are 10 m apart with P below the level of Q.

(a) Find the decrease in kinetic energy of the block as it moves from P to Q. [2]

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(b) Hence find the work done by the force pushing the block up the slope as the block moves from P to Q. [3]

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(c) At the instant the block reaches Q, the force pushing the block up the slope is removed.

Find the time taken, after this instant, for the block to return to P. [4]

193. 9709_W20_qp_41 Q: 1

A particle B of mass 5 kg is at rest on a smooth horizontal table. A particle A of mass 2.5 kg moves on the table with a speed of $6\,\text{m}\,\text{s}^{-1}$ and collides directly with B. In the collision the two particles coalesce.

(a) Find the speed of the combined particle after the collision. [2]

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(b) Find the loss of kinetic energy of the system due to the collision. [3]

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194. 9709_W20_qp_41 Q: 6

A car of mass 1500 kg is pulling a trailer of mass 750 kg up a straight hill of length 800 m inclined at an angle of $\sin^{-1} 0.08$ to the horizontal. The resistances to the motion of the car and trailer are 400 N and 200 N respectively. The car and trailer are connected by a light rigid tow-bar. The car and trailer have speed 30 m s^{-1} at the bottom of the hill and 20 m s^{-1} at the top of the hill.

(a) Use an energy method to find the constant driving force as the car and trailer travel up the hill. [5]

After reaching the top of the hill the system consisting of the car and trailer travels along a straight level road. The driving force of the car's engine is 2400 N and the resistances to motion are unchanged.

(b) Find the acceleration of the system and the tension in the tow-bar. [4]

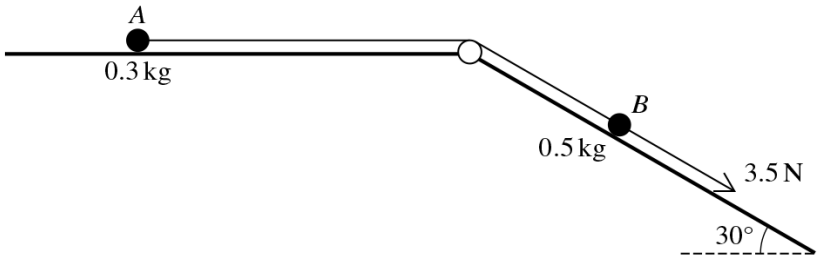
195. 9709_W20_qp_42 Q: 2

A car of mass 1800 kg is travelling along a straight horizontal road. The power of the car's engine is constant. There is a constant resistance to motion of 650 N.

(a) Find the power of the car's engine, given that the car's acceleration is $0.5\,\text{m s}^{-2}$ when its speed is $20\,\text{m s}^{-1}$. [3]

(b) Find the steady speed which the car can maintain with the engine working at this power. [2]

196. 9709_W20_qp_42 Q: 8



Two particles A and B, 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 which is attached to a horizontal plane and to the top of an inclined plane. The particles are initially at rest with A on the horizontal plane and B on the inclined plane, which makes an angle of 30° with the horizontal. The string is taut and B can move on a line of greatest slope of the inclined plane. A force of magnitude 3.5 N is applied to B acting down the plane (see diagram).

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

(b) It is given instead that the two planes are rough. When each particle has moved a distance of 0.6 m from rest, the total amount of work done against friction is 1.1 J.

Use an energy method to find the speed of B when it has moved this distance down the plane. [You should assume that the string is sufficiently long so that A does not hit the pulley when it moves 0.6 m.] [4]

197. 9709_W20_qp_43 Q: 2

A box of mass 5 kg is pulled at a constant speed a distance of 15 m up a rough plane inclined at an angle of 20° to the horizontal. The box moves along a line of greatest slope against a frictional force of 40 N. The force pulling the box is parallel to the line of greatest slope.

(a) Find the work done against friction. [1]

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(b) Find the change in gravitational potential energy of the box. [2]

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(c) Find the work done by the pulling force. [1]

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198. 9709_W20_qp_43 Q: 4

Two small smooth spheres A and B, of equal radii and of masses 4 kg and m kg respectively, lie on a smooth horizontal plane. Initially, sphere B is at rest and A is moving towards B with speed 6 m s^{-1}. After the collision A moves with speed 1.5 m s^{-1} and B moves with speed 3 m s^{-1}.

Find the two possible values of the loss of kinetic energy due to the collision. [6]

199. 9709_W20_qp_43 Q: 6

A car of mass 1600 kg is pulling a caravan of mass 800 kg. The car and the caravan are connected by a light rigid tow-bar. The resistances to the motion of the car and caravan are 400 N and 250 N respectively.

(a) The car and caravan are travelling along a straight horizontal road.

(i) Given that the car and caravan have a constant speed of 25 m s^{-1}, find the power of the car's engine. [2]

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(ii) The engine's power is now suddenly increased to 39 kW. Find the instantaneous acceleration of the car and caravan and find the tension in the tow-bar. [5]

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(b) The car and caravan now travel up a straight hill, inclined at an angle of $\sin^{-1} 0.05$ to the horizontal, at a constant speed of v m s^{-1}. The car's engine is working at 32.5 kW.

Find v. [3]

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200. 9709_m19_qp_42 Q: 4

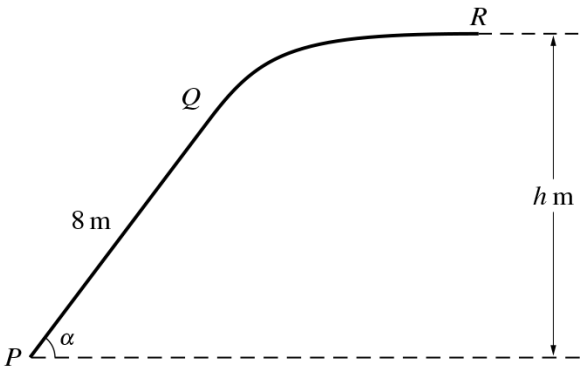
A car of mass 1500 kg is pulling a trailer of mass 300 kg along a straight horizontal road at a constant speed of 20 m s^{-1}. The system of the car and trailer is modelled as two particles, connected by a light rigid horizontal rod. The power of the car's engine is 6000 W. There are constant resistances to motion of R N on the car and 80 N on the trailer.

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

The power of the car's engine is increased to 12 500 W. The resistance forces do not change.

(ii) Find the acceleration of the car and trailer and the tension in the rod at an instant when the speed of the car is 25 m s^{-1}. [5]

201. 9709_m19_qp_42 Q: 7



The diagram shows the vertical cross-section PQR of a slide. The part PQ is a straight line of length 8 m inclined at angle α to the horizontal, where $\sin\alpha = 0.8$. The straight part PQ is tangential to the curved part QR, and R is h m above the level of P. The straight part PQ of the slide is rough and the curved part QR is smooth. A particle of mass 0.25 kg is projected with speed 15 m s^{-1} from P towards Q and comes to rest at R. The coefficient of friction between the particle and PQ is 0.5.

(i) Find the work done by the friction force during the motion of the particle from P to Q. [4]

(ii) Hence find the speed of the particle at Q. [4]

(iii) Find the value of h. [3]

202. 9709_s19_qp_41 Q: 3

A lorry has mass 12 000 kg.

(i) The lorry moves at a constant speed of 5 m s^{-1} up a hill inclined at an angle of θ to the horizontal, where $\sin\theta = 0.08$. At this speed, the magnitude of the resistance to motion on the lorry is 1500 N. Show that the power of the lorry's engine is 55.5 kW. [3]

When the speed of the lorry is v m s^{-1} the magnitude of the resistance to motion is kv^2 N, where k is a constant.

(ii) Show that $k = 60$. [1]

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(iii) The lorry now moves at a constant speed on a straight level road. Given that its engine is still working at 55.5 kW, find the lorry's speed. [3]

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203. 9709_s19_qp_41 Q: 4

A particle of mass 1.3 kg rests on a rough plane inclined at an angle θ to the horizontal, where $\tan\theta = \frac{12}{5}$. The coefficient of friction between the particle and the plane is μ.

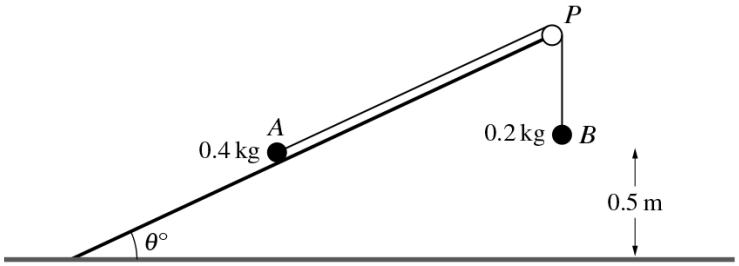
(i) A force of magnitude 20 N parallel to a line of greatest slope of the plane is applied to the particle and the particle is on the point of moving up the plane. Show that $\mu = 1.6$. [4]

The force of magnitude 20 N is now removed.

(ii) Find the acceleration of the particle. [2]

(iii) Find the work done against friction during the first 2 s of motion. [3]

204. 9709_s19_qp_41 Q: 6



Two particles A and B, of masses 0.4 kg and 0.2 kg respectively, are connected by a light inextensible string. Particle A is held on a smooth plane inclined at an angle of $\theta°$ to the horizontal. The string passes over a small smooth pulley P fixed at the top of the plane, and B hangs freely 0.5 m above horizontal ground (see diagram). The particles are released from rest with both sections of the string taut.

(i) Given that the system is in equilibrium, find θ. [3]

(ii) It is given instead that $\theta = 20$. In the subsequent motion particle A does not reach P and B remains at rest after reaching the ground.

(a) Find the tension in the string and the acceleration of the system. [4]

(b) Find the speed of A at the instant B reaches the ground. [2]

(c) Use an energy method to find the total distance A moves up the plane before coming to instantaneous rest. [5]

205. 9709_s19_qp_42 Q: 3

A particle of mass 13 kg is on a rough plane inclined at an angle of θ to the horizontal, where $\tan\theta = \frac{5}{12}$. The coefficient of friction between the particle and the plane is 0.3. A force of magnitude T N, acting parallel to a line of greatest slope, moves the particle a distance of 2.5 m up the plane at a constant speed. Find the work done by this force. [5]

206. 9709_s19_qp_42 Q: 6

A car has mass 1000 kg. When the car is travelling at a steady speed of v m s^{-1}, where $v > 2$, the resistance to motion of the car is $(Av + B)$ N, where A and B are constants. The car can travel along a horizontal road at a steady speed of 18 m s^{-1} when its engine is working at 36 kW. The car can travel up a hill inclined at an angle of θ to the horizontal, where $\sin\theta = 0.05$, at a steady speed of 12 m s^{-1} when its engine is working at 21 kW. Find A and B. [7]

207. 9709_s19_qp_43 Q: 3

A car of mass 1400 kg is travelling up a hill inclined at an angle of 4° to the horizontal. There is a constant resistance to motion of magnitude 1550 N acting on the car.

(i) Given that the engine of the car is working at 30 kW, find the speed of the car at an instant when its acceleration is 0.4 m s^{-2}. [4]

(ii) The greatest possible constant speed at which the car can travel up the hill is $40\,\text{m}\,\text{s}^{-1}$. Find the maximum possible power of the engine. [3]

208. 9709_s19_qp_43 Q: 5

A particle of mass 18 kg is on a plane inclined at an angle of 30° to the horizontal. The particle is projected up a line of greatest slope of the plane with a speed of $20\,\mathrm{m\,s^{-1}}$.

(i) Given that the plane is smooth, use an energy method to find the distance the particle moves up the plane before coming to instantaneous rest. [4]

(ii) Given instead that the plane is rough and the coefficient of friction between the particle and the plane is 0.25, find the speed of the particle as it returns to its starting point. [8]

209. 9709_w19_qp_41 Q: 1

A crane is lifting a load of 1250 kg vertically at a constant speed V m s^{-1}. Given that the power of the crane is a constant 20 kW, find the value of V. [2]

210. 9709_w19_qp_41 Q: 2

The total mass of a cyclist and her bicycle is 75 kg. The cyclist ascends a straight hill of length 0.7 km inclined at 1.5° to the horizontal. Her speed at the bottom of the hill is $10\,\mathrm{m\,s^{-1}}$ and at the top it is $5\,\mathrm{m\,s^{-1}}$. There is a resistance to motion, and the work done against this resistance as the cyclist ascends the hill is 2000 J. The cyclist exerts a constant force of magnitude F N in the direction of motion. Find F. [5]

211. 9709_w19_qp_42 Q: 4

A lorry of mass 25 000 kg travels along a straight horizontal road. There is a constant force of 3000 N resisting the motion.

(i) Find the power required to maintain a constant speed of 30 m s^{-1}. [2]

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The lorry comes to a straight hill inclined at 2° to the horizontal. The driver switches off the engine of the lorry at the point A which is at the foot of the hill. Point B is further up the hill. The speeds of the lorry at A and B are 30 m s^{-1} and 25 m s^{-1} respectively. The resistance force is still 3000 N.

(ii) Use an energy method to find the height of B above the level of A. [5]

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212. 9709_w19_qp_43 Q: 2

A train of mass 150 000 kg ascends a straight slope inclined at $\alpha°$ to the horizontal with a constant driving force of 16 000 N. At a point A on the slope the speed of the train is 45 m s^{-1}. Point B on the slope is 500 m beyond A. At B the speed of the train is 42 m s^{-1}. There is a resistance force acting on the train and the train does 4×10^6 J of work against this resistance force between A and B. Find the value of α. [5]

213. 9709_w19_qp_43 Q: 5

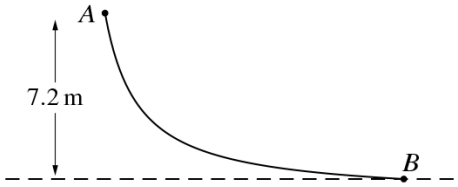
A cyclist is travelling along a straight horizontal road. The total mass of the cyclist and his bicycle is 80 kg. His power output is a constant 240 W. His acceleration when he is travelling at 6 m s^{-1} is 0.3 m s^{-2}.

(i) Show that the resistance to the cyclist's motion is 16 N. [3]

(ii) Find the steady speed that the cyclist can maintain if his power output and the resistance force are both unchanged. [2]

(iii) The cyclist later ascends a straight hill inclined at 3° to the horizontal. His power output and the resistance force are still both unchanged. Find his acceleration when he is travelling at $4\,\mathrm{m\,s^{-1}}$. [3]

214. 9709_m18_qp_42 Q: 3



A girl, of mass 40 kg, slides down a slide in a water park. The girl starts at the point A and slides to the point B which is 7.2 metres vertically below the level of A, as shown in the diagram.

(i) Given that the slide is smooth and that the girl starts from rest at A, find the speed of the girl at B. [2]

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(ii) It is given instead that the slide is rough. On one occasion the girl starts from rest at A and reaches B with a speed of $10\,\text{m s}^{-1}$. On another occasion the girl is pushed from A with an initial speed $V\,\text{m s}^{-1}$ and reaches B with speed $11\,\text{m s}^{-1}$. Given that the work done against friction is the same on both occasions, find V. [3]

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215. 9709_m18_qp_42 Q: 6

A car of mass 1200 kg has a greatest possible constant speed of $60\,\text{m s}^{-1}$ along a straight level road. When the car is travelling at a speed of $v\,\text{m s}^{-1}$ there is a resistive force of magnitude $35v$ N.

(i) Find the greatest possible power of the car. [2]

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(ii) The car travels along a straight level road. Show that, at an instant when its speed is $30\,\text{m s}^{-1}$, the greatest possible acceleration of the car is $2.625\,\text{m s}^{-2}$. [3]

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(iii) The car travels at a constant speed up a hill inclined at an angle of $\sin^{-1}\left(\frac{7}{48}\right)$ to the horizontal. Find the greatest possible speed of the car. [5]

216. 9709_s18_qp_41 Q: 6

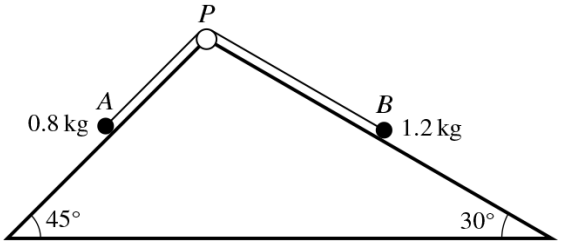
A car has mass 1250 kg.

(i) The car is moving along a straight level road at a constant speed of 36 m s^{-1} and is subject to a constant resistance of magnitude 850 N. Find, in kW, the rate at which the engine of the car is working. [2]

(ii) The car travels at a constant speed up a hill and is subject to the same resistance as in part **(i)**. The hill is inclined at an angle of $\theta°$ to the horizontal, where $\sin\theta° = 0.1$, and the engine is working at 63 kW. Find the speed of the car. [3]

(iii) The car descends the same hill with the engine of the car working at a constant rate of 20 kW. The resistance is not constant. The initial speed of the car is $20\,\text{m}\,\text{s}^{-1}$. Eight seconds later the car has speed $24\,\text{m}\,\text{s}^{-1}$ and has moved 176 m down the hill. Use an energy method to find the total work done against the resistance during the eight seconds. [5]

217. 9709_s18_qp_41 Q: 7



The diagram shows a triangular block with sloping faces inclined to the horizontal at 45° and 30°. Particle A of mass 0.8 kg lies on the face inclined at 45° and particle B of mass 1.2 kg lies on the face inclined at 30°. The particles are connected by a light inextensible string which passes over a small smooth pulley P fixed at the top of the faces. The parts AP and BP of the string are parallel to lines of greatest slope of the respective faces. The particles are released from rest with both parts of the string taut. In the subsequent motion neither particle reaches the pulley and neither particle reaches the bottom of a face.

(i) Given that both faces are smooth, find the speed of A after each particle has travelled a distance of 0.4 m. [6]

(ii) It is given instead that both faces are rough. The coefficient of friction between each particle and a face of the block is μ. Find the value of μ for which the system is in limiting equilibrium. [6]

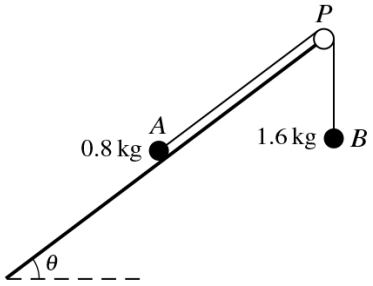
218. 9709_s18_qp_42 Q: 1

A man has mass 80 kg. He runs along a horizontal road against a constant resistance force of magnitude P N. The total work done by the man in increasing his speed from 4 m s^{-1} to 5.5 m s^{-1} while running a distance of 60 metres is 1200 J. Find the value of P. [4]

219. 9709_s18_qp_42 Q: 2

A train of mass 240 000 kg travels up a slope inclined at an angle of 4° to the horizontal. There is a constant resistance of magnitude 18 000 N acting on the train. At an instant when the speed of the train is 15 m s^{-1} its deceleration is 0.2 m s^{-2}. Find the power of the engine of the train. [4]

220. 9709_s18_qp_43 Q: 4



Two particles A and B, of masses 0.8 kg and 1.6 kg respectively, are connected by a light inextensible string. Particle A is placed on a smooth plane inclined at an angle θ to the horizontal, where $\sin\theta = \frac{3}{5}$. The string passes over a small smooth pulley P fixed at the top of the plane, and B hangs freely (see diagram). The section AP of the string is parallel to a line of greatest slope of the plane. The particles are released from rest with both sections of the string taut. Use an energy method to find the speed of the particles after each particle has moved a distance of 0.5 m, assuming that A has not yet reached the pulley. [6]

221. 9709_s18_qp_43 Q: 6

A car of mass 1400 kg travelling at a speed of v m s^{-1} experiences a resistive force of magnitude $40v$ N. The greatest possible constant speed of the car along a straight level road is 56 m s^{-1}.

(i) Find, in kW, the greatest possible power of the car's engine. [2]

(ii) Find the greatest possible acceleration of the car at an instant when its speed on a straight level road is 32 m s^{-1}. [3]

(iii) The car travels down a hill inclined at an angle of $\theta°$ to the horizontal at a constant speed of $50\,\text{m}\,\text{s}^{-1}$. The power of the car's engine is 60 kW. Find the value of θ. [4]

222. 9709_w18_qp_41 Q: 2

A high-speed train of mass 490 000 kg is moving along a straight horizontal track at a constant speed of 85 m s^{-1}. The engines are supplying 4080 kW of power.

(i) Show that the resistance force is 48 000 N. [1]

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(ii) The train comes to a hill inclined at an angle $\theta°$ above the horizontal, where $\sin\theta° = \frac{1}{200}$. Given that the resistance force is unchanged, find the power required for the train to keep moving at the same constant speed of 85 m s^{-1}. [3]

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223. 9709_w18_qp_41 Q: 3

A van of mass 2500 kg descends a hill of length 0.4 km inclined at 4° to the horizontal. There is a constant resistance to motion of 600 N and the speed of the van increases from 20 m s^{-1} to 30 m s^{-1} as it descends the hill. Find the work done by the van's engine as it descends the hill. [5]

224. 9709_w18_qp_42 Q: 6

A car of mass 1200 kg is driving along a straight horizontal road at a constant speed of 15 m s^{-1}. There is a constant resistance to motion of 350 N.

(i) Find the power of the car's engine. [1]

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The car comes to a hill inclined at 1° to the horizontal, still travelling at 15 m s^{-1}.

(ii) The car starts to descend the hill with reduced power and with an acceleration of 0.12 m s^{-2}. Given that there is no change in the resistance force, find the new power of the car's engine at the instant when it starts to descend the hill. [3]

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(iii) When the car is travelling at $20\,\text{m}\,\text{s}^{-1}$ down the hill, the power is cut off and the car gradually slows down. Assuming that the resistance force remains 350 N, find the distance travelled from the moment when the power is cut off until the speed of the car is reduced to $18\,\text{m}\,\text{s}^{-1}$. [4]

225. 9709_w18_qp_42 Q: 7

A particle of mass 0.3 kg is released from rest above a tank containing water. The particle falls vertically, taking 0.8 s to reach the water surface. There is no instantaneous change of speed when the particle enters the water. The depth of water in the tank is 1.25 m. The water exerts a force on the particle resisting its motion. The work done against this resistance force from the instant that the particle enters the water until it reaches the bottom of the tank is 1.2 J.

(i) Use an energy method to find the speed of the particle when it reaches the bottom of the tank. [4]

When the particle reaches the bottom of the tank, it bounces back vertically upwards with initial speed $7\,\text{m}\,\text{s}^{-1}$. As the particle rises through the water, it experiences a constant resistance force of 1.8 N. The particle comes to instantaneous rest t seconds after it bounces on the bottom of the tank.

(ii) Find the value of t. [7]

226. 9709_w18_qp_43 Q: 3

A particle of mass 1.2 kg moves in a straight line AB. It is projected with speed 7.5 m s^{-1} from A towards B and experiences a resistance force. The work done against this resistance force in moving from A to B is 25 J.

(i) Given that AB is horizontal, find the speed of the particle at B. [2]

(ii) It is given instead that AB is inclined at 30° below the horizontal and that the speed of the particle at B is 9 m s^{-1}. The work done against the resistance force remains the same. Find the distance AB. [3]

227. 9709_w18_qp_43 Q: 6

A van of mass 3200 kg travels along a horizontal road. The power of the van's engine is constant and equal to 36 kW, and there is a constant resistance to motion acting on the van.

(i) When the speed of the van is 20 m s^{-1}, its acceleration is 0.2 m s^{-2}. Find the resistance force. [3]

When the van is travelling at 30 m s^{-1}, it begins to ascend a hill inclined at 1.5° to the horizontal. The power is increased and the resistance force is still equal to the value found in part **(i)**.

(ii) Find the power required to maintain this speed of 30 m s^{-1}. [3]

(iii) The engine is now stopped, with the van still travelling at $30\,\text{m}\,\text{s}^{-1}$, and the van decelerates to rest. Find the distance the van moves up the hill from the point at which the engine is stopped until it comes to rest. [4]

228. 9709_m17_qp_42 Q: 1

A particle of mass 0.4 kg is projected with a speed of 12 m s^{-1} up a line of greatest slope of a smooth plane inclined at 30° to the horizontal.

(i) Find the initial kinetic energy of the particle. [1]

(ii) Use an energy method to find the distance the particle moves up the plane before coming to instantaneous rest. [3]

229. 9709_m17_qp_42 Q: 4

A car of mass 900 kg is moving on a straight horizontal road $ABCD$. There is a constant resistance of magnitude 800 N in the sections AB and BC, and a constant resistance of magnitude R N in the section CD. The power of the car's engine is a constant 36 kW.

(i) The car moves from A to B at a constant speed in 120 s. Find the speed of the car and the distance AB. [3]

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The car's engine is switched off at B.

(ii) The distance BC is 450 m. Find the speed of the car at C. [3]

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(iii) The car comes to rest at D. The distance AD is 6637.5 m. Find the deceleration of the car and the value of R. [4]

230. 9709_s17_qp_41 Q: 1

A particle of mass 0.6 kg is dropped from a height of 8 m above the ground. The speed of the particle at the instant before hitting the ground is $10\,\text{m}\,\text{s}^{-1}$. Find the work done against air resistance. [3]

231. 9709_s17_qp_41 Q: 4

A car of mass 800 kg is moving up a hill inclined at $\theta°$ to the horizontal, where $\sin\theta = 0.15$. The initial speed of the car is 8 m s^{-1}. Twelve seconds later the car has travelled 120 m up the hill and has speed 14 m s^{-1}.

(i) Find the change in the kinetic energy and the change in gravitational potential energy of the car. [3]

(ii) The engine of the car is working at a constant rate of 32 kW. Find the total work done against the resistive forces during the twelve seconds. [3]

232. 9709_s17_qp_42 Q: 1

One end of a light inextensible string is attached to a block. The string makes an angle of $\theta°$ with the horizontal. The tension in the string is 20 N. The string pulls the block along a horizontal surface at a constant speed of 1.5 m s^{-1} for 12 s. The work done by the tension in the string is 50 J. Find θ. [3]

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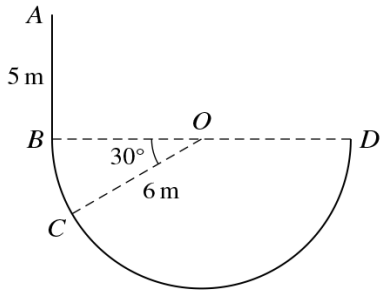
233. 9709_s17_qp_42 Q: 2



The diagram shows a wire $ABCD$ consisting of a straight part AB of length 5 m and a part BCD in the shape of a semicircle of radius 6 m and centre O. The diameter BD of the semicircle is horizontal and AB is vertical. A small ring is threaded onto the wire and slides along the wire. The ring starts from rest at A. The part AB of the wire is rough, and the ring accelerates at a constant rate of 2.5 m s^{-2} between A and B.

(i) Show that the speed of the ring as it reaches B is 5 m s^{-1}. [1]

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The part BCD of the wire is smooth. The mass of the ring is 0.2 kg.

(ii) (a) Find the speed of the ring at C, where angle $BOC = 30°$. [4]

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(b) Find the greatest speed of the ring. [2]

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234. 9709_s17_qp_42 Q: 4

A car of mass 1200 kg is moving on a straight road against a constant force of 850 N resisting the motion.

(i) On a part of the road that is horizontal, the car moves with a constant speed of 42 $m\,s^{-1}$.

(a) Calculate, in kW, the power developed by the engine of the car. [2]

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(b) Given that this power is suddenly increased by 6 kW, find the instantaneous acceleration of the car. [3]

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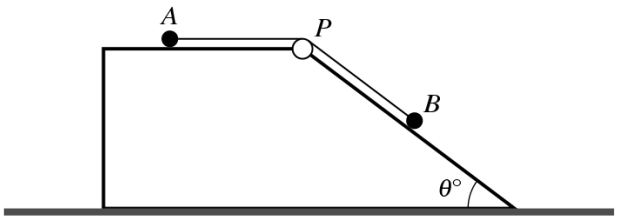
(ii) On a part of the road that is inclined at $\theta°$ to the horizontal, the car moves up the hill at a constant speed of $24\ \text{m s}^{-1}$, with the engine working at 80 kW. Find θ. [4]

235. 9709_s17_qp_42 Q: 6



The diagram shows a fixed block with a horizontal top surface and a surface which is inclined at an angle of $\theta°$ to the horizontal, where $\sin\theta = \frac{3}{5}$. A particle A of mass 0.3 kg rests on the horizontal surface 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 block. The other end of the string is attached to a particle B of mass 1.5 kg which rests on the sloping surface of the block. The system is released from rest with the string taut.

(i) Given that the block is smooth, find the acceleration of particle A and the tension in the string. [5]

(ii) It is given instead that the block is rough. The coefficient of friction between A and the block is μ and the coefficient of friction between B and the block is also μ. In the first 3 seconds of the motion, A does not reach P and B does not reach the bottom of the sloping surface. The speed of the particles after 3 s is 5 m s^{-1}. Find the acceleration of particle A and the value of μ. [9]

236. 9709_s17_qp_43 Q: 1

A man pushes a wheelbarrow of mass 25 kg along a horizontal road with a constant force of magnitude 35 N at an angle of 20° below the horizontal. There is a constant resistance to motion of 15 N. The wheelbarrow moves a distance of 12 m from rest.

(i) Find the work done by the man. [2]

(ii) Find the speed attained by the wheelbarrow after 12 m. [3]

237. 9709_s17_qp_43 Q: 6

A car of mass 1200 kg is travelling along a horizontal road.

(i) It is given that there is a constant resistance to motion.

(a) The engine of the car is working at 16 kW while the car is travelling at a constant speed of 40 m s^{-1}. Find the resistance to motion. [2]

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(b) The power is now increased to 22.5 kW. Find the acceleration of the car at the instant it is travelling at a speed of 45 m s^{-1}. [3]

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(ii) It is given instead that the resistance to motion of the car is $(590 + 2v)$ N when the speed of the car is v m s^{-1}. The car travels at a constant speed with the engine working at 16 kW. Find this speed. [3]

238. 9709_w17_qp_41 Q: 2

The tractor comes to a hill inclined at 4° above the horizontal. The power output is increased to 25 kW and the resistance to motion is unchanged.

(ii) Find the deceleration of the tractor at the instant it begins to climb the hill. [3]

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(iii) Find the constant speed that the tractor could maintain on the hill when working at this power. [2]

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239. 9709_w17_qp_41 Q: 3

A roller-coaster car (including passengers) has a mass of 840 kg. The roller-coaster ride includes a section where the car climbs a straight ramp of length 8 m inclined at 30° above the horizontal. The car then immediately descends another ramp of length 10 m inclined at 20° below the horizontal. The resistance to motion acting on the car is 640 N throughout the motion.

(i) Find the total work done against the resistance force as the car ascends the first ramp and descends the second ramp. [2]

(ii) The speed of the car at the bottom of the first ramp is 14 m s^{-1}. Use an energy method to find the speed of the car when it reaches the bottom of the second ramp. [4]

240. 9709_w17_qp_42 Q: 5

A cyclist is riding up a straight hill inclined at an angle α to the horizontal, where $\sin\alpha = 0.04$. The total mass of the bicycle and rider is 80 kg. The cyclist is riding at a constant speed of 4 m s^{-1}. There is a force resisting the motion. The work done by the cyclist against this resistance force over a distance of 25 m is 600 J.

(i) Find the power output of the cyclist. [4]

The cyclist reaches the top of the hill, where the road becomes horizontal, with speed $4\,\text{m}\,\text{s}^{-1}$. The cyclist continues to work at the same rate on the horizontal part of the road.

(ii) Find the speed of the cyclist 10 seconds after reaching the top of the hill, given that the work done by the cyclist during this period against the resistance force is 1200 J. [4]

241. 9709_w17_qp_43 Q: 2

A lorry of mass 7850 kg travels on a straight hill which is inclined at an angle of 3° to the horizontal. There is a constant resistance to motion of 1480 N.

(i) Find the power of the lorry's engine when the lorry is going up the hill at a constant speed of $10\,\text{m s}^{-1}$. [3]

(ii) Find the power of the lorry's engine at an instant when the lorry is going down the hill at a speed of $15\,\text{m s}^{-1}$ with an acceleration of $0.8\,\text{m s}^{-2}$. [3]

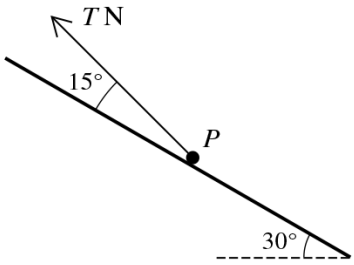
242. 9709_w17_qp_43 Q: 4

Two particles A and B have masses 0.35 kg and 0.45 kg respectively. The particles are attached to the ends of a light inextensible string which passes over a small fixed smooth pulley which is 1 m above horizontal ground. Initially particle A is held at rest on the ground vertically below the pulley, with the string taut. Particle B hangs vertically below the pulley at a height of 0.64 m above the ground. Particle A is released.

(i) Find the speed of A at the instant that B reaches the ground. [5]

(ii) Assuming that B does not bounce after it reaches the ground, find the total distance travelled by A between the instant that B reaches the ground and the instant when the string becomes taut again. [2]

243. 9709_w17_qp_43 Q: 7



A particle P of mass 0.2 kg rests on a rough plane inclined at 30° to the horizontal. The coefficient of friction between the particle and the plane is 0.3. A force of magnitude T N acts upwards on P at 15° above a line of greatest slope of the plane (see diagram).

(i) Find the least value of T for which the particle remains at rest. [6]

The force of magnitude T N is now removed. A new force of magnitude 0.25 N acts on P up the plane, parallel to a line of greatest slope of the plane. Starting from rest, P slides down the plane. After moving a distance of 3 m, P passes through the point A.

(ii) Use an energy method to find the speed of P at A. [5]

244. 9709_m16_qp_42 Q: 1

A cyclist has mass 85 kg and rides a bicycle of mass 20 kg. The cyclist rides along a horizontal road against a total resistance force of 40 N. Find the total work done by the cyclist in increasing his speed from 5 m s^{-1} to 10 m s^{-1} while travelling a distance of 50 m. [3]

245. 9709_m16_qp_42 Q: 2

A constant resistance of magnitude 1350 N acts on a car of mass 1200 kg.

(i) The car is moving along a straight level road at a constant speed of $32\,\text{m}\,\text{s}^{-1}$. Find, in kW, the rate at which the engine of the car is working. [2]

(ii) The car travels at a constant speed up a hill inclined at an angle of θ to the horizontal, where $\sin\theta = 0.1$, with the engine working at 76.5 kW. Find this speed. [3]

246. 9709_m16_qp_42 Q: 5

A car of mass 1200 kg is pulling a trailer of mass 800 kg up a hill inclined at an angle α to the horizontal, where $\sin\alpha = 0.1$. The system of the car and the trailer is modelled as two particles connected by a light inextensible cable. The driving force of the car's engine is 2500 N and the resistances to the car and trailer are 100 N and 150 N respectively.

(i) Find the acceleration of the system and the tension in the cable. [4]

(ii) When the car and trailer are travelling at a speed of $30\,\text{m s}^{-1}$, the driving force becomes zero. The cable remains taut. Find the time, in seconds, before the system comes to rest. [3]

247. 9709_s16_qp_41 Q: 2

A box of mass 25 kg is pulled, at a constant speed, a distance of 36 m up a rough plane inclined at an angle of 20° to the horizontal. The box moves up a line of greatest slope against a constant frictional force of 40 N. The force pulling the box is parallel to the line of greatest slope. Find

(i) the work done against friction, [1]

(ii) the change in gravitational potential energy of the box, [2]

(iii) the work done by the pulling force. [2]

248. 9709_s16_qp_41 Q: 3

A car of mass 1000 kg is moving along a straight horizontal road against resistances of total magnitude 300 N.

(i) Find, in kW, the rate at which the engine of the car is working when the car has a constant speed of 40 $m\,s^{-1}$. [3]

(ii) Find the acceleration of the car when its speed is 25 $m\,s^{-1}$ and the engine is working at 90% of the power found in part **(i)**. [3]

249. 9709_s16_qp_41 Q: 7

A particle of mass 30 kg is on a plane inclined at an angle of 20° to the horizontal. Starting from rest, the particle is pulled up the plane by a force of magnitude 200 N acting parallel to a line of greatest slope.

(i) Given that the plane is smooth, find

(a) the acceleration of the particle, [2]

(b) the change in kinetic energy after the particle has moved 12 m up the plane. [2]

(ii) It is given instead that the plane is rough and the coefficient of friction between the particle and the plane is 0.12.

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

(b) The direction of the force of magnitude 200 N is changed, and the force now acts at an angle of 10° above the line of greatest slope. Find the acceleration of the particle. [4]

250. 9709_s16_qp_42 Q: 3

A particle of mass 8 kg is projected with a speed of 5 m s^{-1} up a line of greatest slope of a rough plane inclined at an angle α to the horizontal, where $\sin\alpha = \frac{5}{13}$. The motion of the particle is resisted by a constant frictional force of magnitude 15 N. The particle comes to instantaneous rest after travelling a distance x m up the plane.

(i) Express the change in gravitational potential energy of the particle in terms of x. [2]

(ii) Use an energy method to find x. [4]

251. 9709_s16_qp_42 Q: 6

A car of mass 1100 kg is moving on a road against a constant force of 1550 N resisting the motion.

(i) The car moves along a straight horizontal road at a constant speed of 40 m s^{-1}.

(a) Calculate, in kW, the power developed by the engine of the car. [2]

(b) Given that this power is suddenly decreased by 22 kW, find the instantaneous deceleration of the car. [3]

(ii) The car now travels at constant speed up a straight road inclined at 8° to the horizontal, with the engine working at 80 kW. Assuming the resistance force remains the same, find this constant speed. [3]

252. 9709_s16_qp_43 Q: 1

A particle of mass 8 kg is pulled at a constant speed a distance of 20 m up a rough plane inclined at an angle of 30° to the horizontal by a force acting along a line of greatest slope.

(i) Find the change in gravitational potential energy of the particle. [2]

(ii) The total work done against gravity and friction is 1146 J. Find the frictional force acting on the particle. [2]

253. 9709_s16_qp_43 Q: 5

The motion of a car of mass 1400 kg is resisted by a constant force of magnitude 650 N.

(i) Find the constant speed of the car on a horizontal road, assuming that the engine works at a rate of 20 kW. [2]

(ii) The car is travelling at a constant speed of $10\,\text{m}\,\text{s}^{-1}$ up a hill inclined at an angle of θ to the horizontal, where $\sin\theta = \frac{1}{7}$. Find the power of the car's engine. [3]

(iii) The car descends the same hill with the engine working at 80% of the power found in part **(ii)**. Find the acceleration of the car at an instant when the speed is $20\,\text{m}\,\text{s}^{-1}$. [3]

254. 9709_s16_qp_43 Q: 6

Two particles of masses 1.3 kg and 0.7 kg are connected by a light inextensible string that passes over a fixed smooth pulley. The particles are held at the same vertical height with the string taut. The distance of each particle above a horizontal plane is 2 m, and the distance of each particle below the pulley is 4 m. The particles are released from rest.

(i) Find

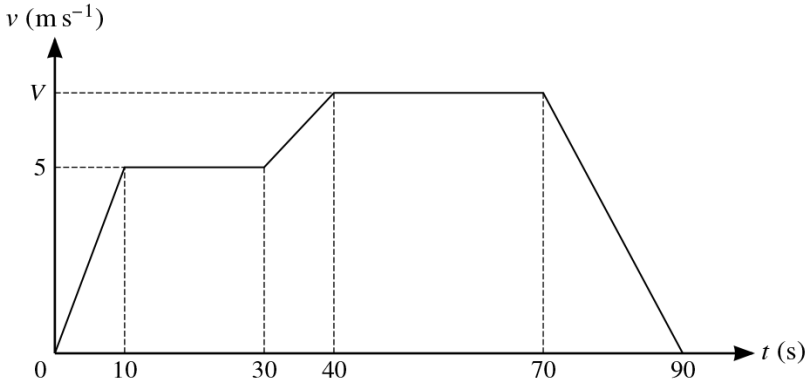
(a) the tension in the string before the particle of mass 1.3 kg reaches the plane,

(b) the time taken for the particle of mass 1.3 kg to reach the plane.

[6]

(ii) Find the greatest height of the particle of mass 0.7 kg above the plane. [4]

255. 9709_w16_qp_41 Q: 5



The diagram shows a velocity-time graph which models the motion of a cyclist. The graph consists of five straight line segments. The cyclist accelerates from rest to a speed of 5 m s^{-1} over a period of 10 s, and then travels at this speed for a further 20 s. The cyclist then descends a hill, accelerating to speed V m s^{-1} over a period of 10 s. This speed is maintained for a further 30 s. The cyclist then decelerates to rest over a period of 20 s.

(i) Find the acceleration of the cyclist during the first 10 seconds. [1]

(ii) Show that the total distance travelled by the cyclist in the 90 seconds of motion may be expressed as $(45V + 150)$ m. Hence find V, given that the total distance travelled by the cyclist is 465 m. [3]

(iii) The combined mass of the cyclist and the bicycle is 80 kg. The cyclist experiences a constant resistance to motion of 20 N. Use an energy method to find the vertical distance which the cyclist descends during the downhill section from $t = 30$ to $t = 40$, assuming that the cyclist does no work during this time. [4]

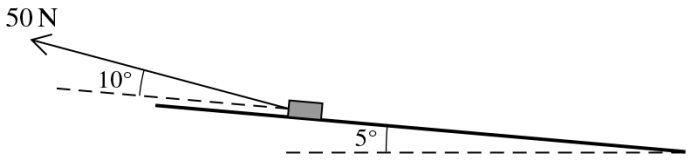
256. 9709_w16_qp_41 Q: 6

A block of mass 25 kg is pulled along horizontal ground by a force of magnitude 50 N inclined at 10° above the horizontal. The block starts from rest and travels a distance of 20 m. There is a constant resistance force of magnitude 30 N opposing motion.

(i) Find the work done by the pulling force. [2]

(ii) Use an energy method to find the speed of the block when it has moved a distance of 20 m. [2]

(iii) Find the greatest power exerted by the 50 N force. [2]



After the block has travelled the 20 m, it comes to a plane inclined at 5° to the horizontal. The force of 50 N is now inclined at an angle of 10° to the plane and pulls the block directly up the plane (see diagram). The resistance force remains 30 N.

(iv) Find the time it takes for the block to come to rest from the instant when it reaches the foot of the inclined plane. [4]

257. 9709_w16_qp_42 Q: 4

A girl on a sledge starts, with a speed of $5\,\text{m}\,\text{s}^{-1}$, at the top of a slope of length 100 m which is at an angle of 20° to the horizontal. The sledge slides directly down the slope.

(i) Given that there is no resistance to the sledge's motion, find the speed of the sledge at the bottom of the slope. [3]

(ii) It is given instead that the sledge experiences a resistance to motion such that the total work done against the resistance is 8500 J, and the speed of the sledge at the bottom of the slope is $21\,\text{m}\,\text{s}^{-1}$. Find the total mass of the girl and the sledge. [3]

258. 9709_w16_qp_42 Q: 6

A van of mass 3000 kg is pulling a trailer of mass 500 kg along a straight horizontal road at a constant speed of 25 m s^{-1}. The system of the van and the trailer is modelled as two particles connected by a light inextensible cable. There is a constant resistance to motion of 300 N on the van and 100 N on the trailer.

(i) Find the power of the van's engine. [2]

(ii) Write down the tension in the cable. [1]

The van reaches the bottom of a hill inclined at 4° to the horizontal with speed 25 m s^{-1}. The power of the van's engine is increased to 25 000 W.

(iii) Assuming that the resistance forces remain the same, find the new tension in the cable at the instant when the speed of the van up the hill is 20 m s^{-1}. [5]

259. 9709_w16_qp_43 Q: 1

A crane is used to raise a block of mass 50 kg vertically upwards at constant speed through a height of 3.5 m. There is a constant resistance to motion of 25 N.

(i) Find the work done by the crane. [3]

(ii) Given that the time taken to raise the block is 2 s, find the power of the crane. [2]

260. 9709_w16_qp_43 Q: 6

A cyclist is cycling with constant power of 160 W along a horizontal straight road. There is a constant resistance to motion of 20 N. At an instant when the cyclist's speed is $5\,m\,s^{-1}$, his acceleration is $0.15\,m\,s^{-2}$.

(i) Show that the total mass of the cyclist and bicycle is 80 kg. [3]

The cyclist comes to a hill inclined at 2° to the horizontal. When the cyclist starts climbing the hill, he increases his power to a constant 300 W. The resistance to motion remains 20 N.

(ii) Show that the steady speed up the hill which the cyclist can maintain when working at this power is $6.26\,m\,s^{-1}$, correct to 3 significant figures. [2]

(iii) Find the acceleration at an instant when the cyclist is travelling at 90% of the speed in part **(ii)**. [4]

261. 9709_w16_qp_43 Q: 7

A box of mass 50 kg is at rest on a plane inclined at 10° to the horizontal.

(i) Find an inequality for the coefficient of friction between the box and the plane. [2]

In fact the coefficient of friction between the box and the plane is 0.19.

(ii) A girl pushes the box with a force of 50 N, acting down a line of greatest slope of the plane, for a distance of 5 m. She then stops pushing. Use an energy method to find the speed of the box when it has travelled a further 5 m. [5]

The box then comes to a plane inclined at 20° below the horizontal. The box moves down a line of greatest slope of this plane. The coefficient of friction is still 0.19 and the girl is not pushing the box.

(iii) Find the acceleration of the box. [2]

262. 9709_s15_qp_41 Q: 1

A block B of mass 2.7 kg is pulled at constant speed along a straight line on a rough horizontal floor. The pulling force has magnitude 25 N and acts at an angle of θ above the horizontal. The normal component of the contact force acting on B has magnitude 20 N.

(i) Show that $\sin\theta = 0.28$. [2]

(ii) Find the work done by the pulling force in moving the block a distance of 5 m. [2]

263. 9709_s15_qp_41 Q: 4

A lorry of mass 14 000 kg moves along a road starting from rest at a point O. It reaches a point A, and then continues to a point B which it reaches with a speed of 24 m s^{-1}. The part OA of the road is straight and horizontal and has length 400 m. The part AB of the road is straight and is inclined downwards at an angle of $\theta°$ to the horizontal and has length 300 m.

(i) For the motion from O to B, find the gain in kinetic energy of the lorry and express its loss in potential energy in terms of θ. [3]

The resistance to the motion of the lorry is 4800 N and the work done by the driving force of the lorry from O to B is 5000 kJ.

(ii) Find the value of θ. [3]

264. 9709_s15_qp_41 Q: 5

A cyclist and her bicycle have a total mass of 84 kg. She works at a constant rate of P W while moving on a straight road which is inclined to the horizontal at an angle θ, where $\sin\theta = 0.1$. When moving uphill, the cyclist's acceleration is $1.25\,\text{m s}^{-2}$ at an instant when her speed is $3\,\text{m s}^{-1}$. When moving downhill, the cyclist's acceleration is $1.25\,\text{m s}^{-2}$ at an instant when her speed is $10\,\text{m s}^{-1}$. The resistance to the cyclist's motion, whether the cyclist is moving uphill or downhill, is R N. Find the values of P and R. [8]

265. 9709_s15_qp_42 Q: 1

One end of a light inextensible string is attached to a block. The string makes an angle of 60° above the horizontal and is used to pull the block in a straight line on a horizontal floor with acceleration $0.5\,\text{m s}^{-2}$. The tension in the string is 8 N. The block starts to move with speed $0.3\,\text{m s}^{-1}$. For the first 5 s of the block's motion, find

(i) the distance travelled, [2]

(ii) the work done by the tension in the string. [2]

266. 9709_s15_qp_42 Q: 2

The total mass of a cyclist and his cycle is 80 kg. The resistance to motion is zero.

(i) The cyclist moves along a horizontal straight road working at a constant rate of P W. Find the value of P given that the cyclist's speed is 5 m s^{-1} when his acceleration is 1.2 m s^{-2}. [2]

(ii) The cyclist moves up a straight hill inclined at an angle α, where $\sin\alpha = 0.035$. Find the acceleration of the cyclist at an instant when he is working at a rate of 450 W and has speed 3.6 m s^{-1}. [3]

267. 9709_s15_qp_42 Q: 3

A plane is inclined at an angle of $\sin^{-1}\left(\frac{1}{8}\right)$ to the horizontal. A and B are two points on the same line of greatest slope with A higher than B. The distance AB is 12 m. A small object P of mass 8 kg is released from rest at A and slides down the plane, passing through B with speed 4.5 m s^{-1}. For the motion of P from A to B, find

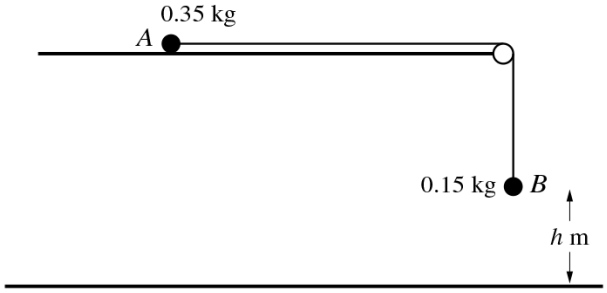
(i) the increase in kinetic energy of P and the decrease in potential energy of P, [3]

(ii) the magnitude of the constant resisting force that opposes the motion of P. [2]

268. 9709_s15_qp_43 Q: 1

A block is pulled along a horizontal floor by a horizontal rope. The tension in the rope is 500 N and the block moves at a constant speed of 2.75 m s^{-1}. Find the work done by the tension in 40 s and find the power applied by the tension. [4]

269. 9709_s15_qp_43 Q: 2



Particles A and B, of masses 0.35 kg and 0.15 kg respectively, are attached to the ends of a light inextensible string. A is held at rest on a smooth horizontal surface with the string passing over a small smooth pulley fixed at the edge of the surface. B hangs vertically below the pulley at a distance h m above the floor (see diagram). A is released and the particles move. B reaches the floor and A subsequently reaches the pulley with a speed of 3 m s^{-1}.

(i) Explain briefly why the speed with which B reaches the floor is 3 m s^{-1}. [1]

(ii) Find the value of h. [4]

270. 9709_s15_qp_43 Q: 3

A car of mass 860 kg travels along a straight horizontal road. The power provided by the car's engine is P W and the resistance to the car's motion is R N. The car passes through one point with speed 4.5 m s^{-1} and acceleration 4 m s^{-2}. The car passes through another point with speed 22.5 m s^{-1} and acceleration 0.3 m s^{-2}. Find the values of P and R. [6]

271. 9709_s15_qp_43 Q: 4

A lorry of mass 12 000 kg moves up a straight hill of length 500 m, starting at the bottom with a speed of 24 m s^{-1} and reaching the top with a speed of 16 m s^{-1}. The top of the hill is 25 m above the level of the bottom of the hill. The resistance to motion of the lorry is 7500 N. Find the driving force of the lorry. [6]

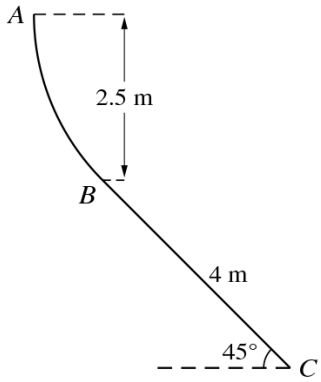
272. 9709_w15_qp_41 Q: 1

A weightlifter performs an exercise in which he raises a mass of 200 kg from rest vertically through a distance of 0.7 m and holds it at that height.

(i) Find the work done by the weightlifter. [2]

(ii) Given that the time taken to raise the mass is 1.2 s, find the average power developed by the weightlifter. [2]

273. 9709_w15_qp_42 Q: 4



The diagram shows a vertical cross-section ABC of a surface. The part of the surface containing AB is smooth and A is 2.5 m above the level of B. The part of the surface containing BC is rough and is at 45° to the horizontal. The distance BC is 4 m (see diagram). A particle P of mass 0.2 kg is released from rest at A and moves in contact with the curve AB and then with the straight line BC. The coefficient of friction between P and the part of the surface containing BC is 0.4. Find the speed with which P reaches C. [6]

274. 9709_w15_qp_42 Q: 7

A car of mass 1600 kg moves with constant power 14 kW as it travels along a straight horizontal road. The car takes 25 s to travel between two points A and B on the road.

(i) Find the work done by the car's engine while the car travels from A to B. [2]

The resistance to the car's motion is constant and equal to 235 N. The car has accelerations at A and B of 0.5 m s^{-2} and 0.25 m s^{-2} respectively. Find

(ii) the gain in kinetic energy by the car in moving from A to B, [5]

(iii) the distance AB. [3]

275. 9709_w15_qp_43 Q: 5

A cyclist and his bicycle have a total mass of 90 kg. The cyclist starts to move with speed $3\,\text{m s}^{-1}$ from the top of a straight hill, of length 500 m, which is inclined at an angle of $\sin^{-1} 0.05$ to the horizontal. The cyclist moves with constant acceleration until he reaches the bottom of the hill with speed $5\,\text{m s}^{-1}$. The cyclist generates 420 W of power while moving down the hill. The resistance to the motion of the cyclist and his bicycle, R N, and the cyclist's speed, $v\,\text{m s}^{-1}$, both vary.

(i) Show that $R = \dfrac{420}{v} + 43.56$. [5]

(ii) Find the cyclist's speed at the mid-point of the hill. Hence find the decrease in the value of R when the cyclist moves from the top of the hill to the mid-point of the hill, and when the cyclist moves from the mid-point of the hill to the bottom of the hill. [3]

276. 9709_w15_qp_43 Q: 7

A straight hill AB has length 400 m with A at the top and B at the bottom and is inclined at an angle of 4° to the horizontal. A straight horizontal road BC has length 750 m. A car of mass 1250 kg has a speed of 5 m s^{-1} at A when starting to move down the hill. While moving down the hill the resistance to the motion of the car is 2000 N and the driving force is constant. The speed of the car on reaching B is 8 m s^{-1}.

(i) By using work and energy, find the driving force of the car. [5]

On reaching B the car moves along the road BC. The driving force is constant and twice that when the car was on the hill. The resistance to the motion of the car continues to be 2000 N. Find

(ii) the acceleration of the car while moving from B to C, [3]

(iii) the power of the car's engine as the car reaches C. [3]