Y	Q	Equations of Motion
24	12	A particle accelerates at $\frac{8}{3}\,\mathrm{m\,s^{-2}}$ from rest for a time of 15 seconds. It then decelerates. The velocity of the particle during the deceleration is given by $v = 905\,e^{-0.20793t}\,\mathrm{m\,s^{-1}}$, where t is the time in seconds from the start of the motion. The particle hits a barrier and stops after a total time of 35 seconds. (a) Sketch a velocity-time graph for the particle. Show clearly all important information. **2** (b) Determine the total distance the particle travels during its motion. **4**
24	15	A motorbike and a car are at rest and beside each other. The car moves off first with uniform acceleration of $0.8\,\mathrm{m\,s^{-2}}$. (a) Find the distance the car has travelled after 5 seconds. **1** The motorbike then accelerates uniformly in the same direction at $1.8\,\mathrm{m\,s^{-2}}$. (b) Find the time it takes for the motorbike to accelerate in order to draw level with the car. **4** At the point when the motorbike and car are level, they see a sign for a road junction 200 metres ahead. (c) If the driver of the car takes 0.8 seconds to react, find the necessary deceleration if the car is to stop at the junction. **3**
24	18	A box is placed on a rough plane inclined at 10° to the horizontal. The total mass of the box and its contents when full is 60 kg. The box can be moved up the plane with constant velocity by a force of magnitude P newtons parallel to the slope. When the box is empty, it has a mass of 40 kg and can be moved down the plane with constant velocity by a force of magnitude Q newtons. Q acts in the opposite direction to P and $P = 5Q$. (a) Show that the value of the coefficient of friction between the box and the plane is 0.327 to three significant figures. **5** The full box is now attached to a light inextensible cable. Starting from rest, the box is pulled up the plane by the cable. The tension in the cable is of magnitude 300 newtons and acts parallel to the slope. After 10 seconds the cable snaps and the box continues to move until it comes to rest. (b) Calculate the total distance the box travels up the plane. **6**
23	10	A particle C is fired vertically upwards, from horizontal ground, with speed $10.5\,\mathrm{m\,s^{-1}}$. At the same instant another particle D is fired vertically upwards, from a point 2 metres above the ground. (a) Find the initial speed of D given that both particles reach the same maximum height. **3** (b) Show that, at the instant when C and D are at the same height, the particles have the same speed and are moving in opposite directions. **4**

22	6	A body moves with an initial velocity u m s^{-1} in a straight line on a smooth horizontal surface. It travels with a constant acceleration of a m s^{-2}. After t seconds it has a velocity v m s^{-1}. (a) Use calculus to show that $v = u + at$. (b) Hence, derive an expression for its displacement, s metres, from its original position in terms of u, a and t.	 2 2
18	1	A boat accelerates steadily from a speed of 10 m s^{-1} to 14 m s^{-1} over a distance of 1·2 kilometres. The boat continues to accelerate at the same rate for a further two minutes. The engines are then put into reverse to produce an immediate deceleration of the same magnitude as the previous acceleration. This brings the boat to rest. Calculate the total distance travelled by the boat since it started to accelerate.	 5
18	16	Two runners are taking part in a relay race and preparing to hand over the baton. They are running in the same straight line when they exchange the baton. Runner *P* is running at a constant speed of 12 m s^{-1} when he decelerates at 4 m s^{-2} in preparation for the baton change, at which point he must be travelling at 9 m s^{-1}. He continues to decelerate at the same rate until he comes to rest. Runner *Q* takes the baton 3 seconds after starting running with a constant acceleration. He has achieved a speed of 9 m s^{-1} when the baton is exchanged and continues to accelerate to a maximum speed of 12 m s^{-1}. (a) (i) Sketch a velocity/time graph to represent both runners, annotating all relevant points on your graph. (ii) For how many seconds has *P* decelerated before baton change? (b) At the point when the baton is exchanged, *Q* is 0·8 metres ahead of *P*. How far is *P* behind *Q* when *Q* starts to run?	 2 1 5
16	6	A remote controlled aircraft is flown from point A to point B. It accelerates for 10 seconds at a constant rate from rest to a take-off speed of 15 m s^{-1}. Once airborne, it accelerates for a further 20 seconds at a slower constant rate to a cruising speed of u m s^{-1}. It maintains this speed for 60 seconds until it lands. The aircraft then decelerates for 10 seconds to a complete stop. (a) Sketch a speed-time graph of the journey, clearly showing all the important information. (b) (i) If the distance travelled from A to B is 1·725 km, calculate the value of u. (ii) State one assumption you have made about the path of the aircraft during your calculations.	 2 2 1

16 (Sp)	4	A train travels from Glasgow to Stirling. It starts from rest and accelerates uniformly for the first 9 km of its journey. It then travels for 46·8 km at a uniform velocity, before decelerating uniformly to rest in 7·2 km. The total journey time is 33 minutes. (a) Sketch a velocity-time graph with appropriate units to represent this journey. (b) Calculate, in km h^{-1}, the maximum speed reached by the train. (c) State **one** assumption you have made in answering this question.	 **2** **4** **1**
16 (Sp)	5	A particle is projected vertically upwards at a speed of 14·8 m s^{-1} from a point O. Two seconds later a second particle is projected vertically upwards from O at a speed of 5·2 m s^{-1}. (a) Calculate the value of t when the two particles collide assuming that the only force acting is that due to gravity. (b) Determine the distance the particles are above O when they collide.	 **4** **1**