Materials required for examination	**Items included with question papers**
Mathematical Formulae (Pink)	Nil

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions to Candidates

In the boxes on the answer book, write the name of the examining body (Edexcel), your centre number, candidate number, the unit title (Mechanics M1), the paper reference (6677), your surname, other name and signature.

Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}.

When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
There are 7 questions in this question paper.
The total mark for this paper is 75.

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You must show sufficient working to make your methods clear to the Examiner.
Answers without working may not gain full credit.

1. Two particles A and B, of mass 5m kg and 2m kg respectively, are moving in opposite directions along the same straight horizontal line. The particles collide directly. Immediately before the collision, the speeds of A and B are 3 m s^{-1} and 4 m s^{-1} respectively. The direction of motion of A is unchanged by the collision. Immediately after the collision, the speed of A is 0.8 m s^{-1}.

(*a*) Find the speed of B immediately after the collision.

(**3**)

In the collision, the magnitude of the impulse exerted on A by B is 3.3 N s.

(*b*) Find the value of *m*.
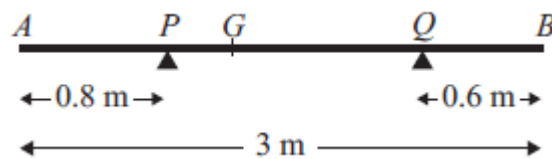
(**3**)

2.

Figure 1

A non-uniform rod AB has length 3 m and mass 4.5 kg. The rod rests in equilibrium, in a horizontal position, on two smooth supports at P and at Q, where $AP = 0.8$ m and $QB = 0.6$ m, as shown in Figure 1. The centre of mass of the rod is at G. Given that the magnitude of the reaction of the support at P on the rod is twice the magnitude of the reaction of the support at Q on the rod, find

(*a*) the magnitude of the reaction of the support at Q on the rod,

(**3**)
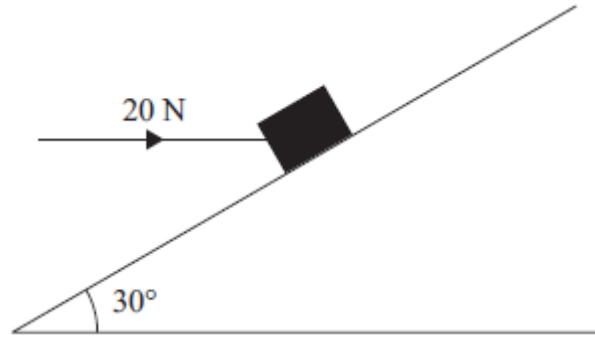
(*b*) the distance AG.

(**4**)

3.

Figure 2

A box of mass 5 kg lies on a rough plane inclined at 30° to the horizontal. The box is held in equilibrium by a horizontal force of magnitude 20 N, as shown in Figure 2. The force acts in a vertical plane containing a line of greatest slope of the inclined plane.

The box is in equilibrium and on the point of moving down the plane. The box is modelled as a particle.

Find

(*a*) the magnitude of the normal reaction of the plane on the box,

(4)

(*b*) the coefficient of friction between the box and the plane.

(5)

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4.   A car is moving on a straight horizontal road. At time $t = 0$, the car is moving with speed 20 m s^{-1} and is at the point *A*. The car maintains the speed of 20 m s^{-1} for 25 s. The car then moves with constant deceleration 0.4 m s^{-2}, reducing its speed from 20 m s^{-1} to 8 m s^{-1}. The car then moves with constant speed 8 m s^{-1} for 60 s. The car then moves with constant acceleration until it is moving with speed 20 m s^{-1} at the point *B*.

(*a*) Sketch a speed-time graph to represent the motion of the car from *A* to *B*.

(3)

(*b*) Find the time for which the car is decelerating.

(2)

Given that the distance from *A* to *B* is 1960 m,

(*c*) find the time taken for the car to move from *A* to *B*.

(8)

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5. A particle *P* is projected vertically upwards from a point *A* with speed *u* m s^{-1}. The point *A* is 17.5 m above horizontal ground. The particle *P* moves freely under gravity until it reaches the ground with speed 28 m s^{-1}.

(*a*) Show that $u = 21$.

(3)

At time *t* seconds after projection, *P* is 19 m above *A*.

(*b*) Find the possible values of *t*.

(5)

The ground is soft and, after *P* reaches the ground, *P* sinks vertically downwards into the ground before coming to rest. The mass of *P* is 4 kg and the ground is assumed to exert a constant resistive force of magnitude 5000 N on *P*.

(*c*) Find the vertical distance that *P* sinks into the ground before coming to rest.

(4)

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6. [*In this question i and j are horizontal unit vectors due east and due north respectively and position vectors are given with respect to a fixed origin.*]

A ship *S* is moving with constant velocity (−12**i** + 7.5**j**) km h^{-1}.

(*a*) Find the direction in which *S* is moving, giving your answer as a bearing.

(3)

At time t hours after noon, the position vector of *S* is *s* km. When $t = 0$, s = 40**i** − 6**j**.

(*b*) Write down s in terms of *t*.

(2)

A fixed beacon *B* is at the point with position vector (7**i** + 12.5**j**) km.

(*c*) Find the distance of *S* from *B* when $t = 3$

(4)

(*d*) Find the distance of *S* from *B* when *S* is due north of *B*.

(4)

7.

Figure 3

Two particles P and Q, of mass 0.3 kg and 0.5 kg respectively, are joined by a light horizontal rod. The system of the particles and the rod is at rest on a horizontal plane. At time $t = 0$, a constant force **F** of magnitude 4 N is applied to Q in the direction PQ, as shown in Figure 3. The system moves under the action of this force until $t = 6$ s. During the motion, the resistance to the motion of P has constant magnitude 1 N and the resistance to the motion of Q has constant magnitude 2 N.

Find

(a) the acceleration of the particles as the system moves under the action of **F**,

(3)

(b) the speed of the particles at $t = 6$ s,

(2)

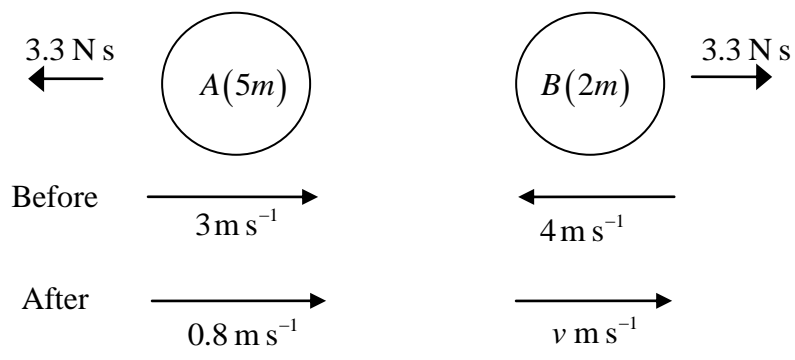(c) the tension in the rod as the system moves under the action of **F**.

(3)
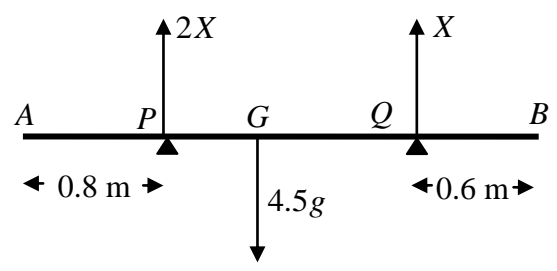
At $t = 6$ s, **F** is removed and the system decelerates to rest. The resistances to motion are unchanged. Find
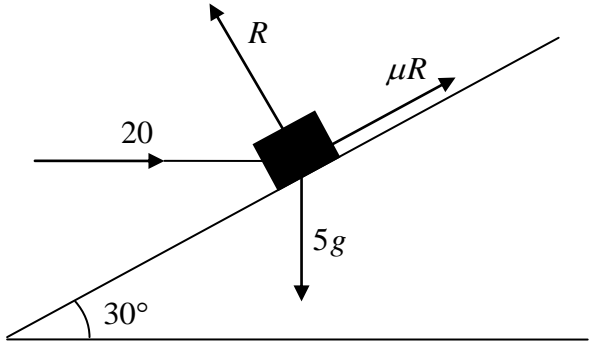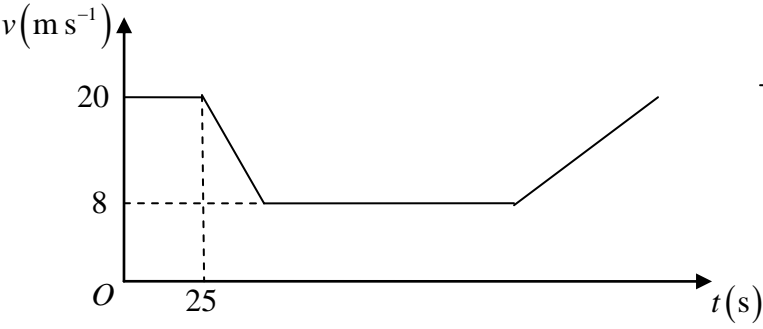
(d) the distance moved by P as the system decelerates,

(4)

(e) the thrust in the rod as the system decelerates.

(3)

TOTAL FOR PAPER: 75 MARKS

END

Question Number	Scheme	Marks
1.		
	(a) CLM $5m \times 3 - 2m \times 4 = 5m \times 0.8 + 2mv$	M1 A1
	Leading to $v = 1.5$ $\left(\text{Speed is } 1.5\text{ m s}^{-1}\right)$	A1 **(3)**
	(b) Impulse for A $5m(0.8 - 3) = -3.3$	M1 A1
	Leading to $m = 0.3$	A1 **(3)**
		[6]
2.		
	(a) ↑ $2X + X = 4.5g$	M1 A1
	Leading to $X = \dfrac{3g}{2}$ or 14.7 or 15 $\left(\text{N}\right)$	A1 **(3)**
	(b) M(A) $4.5g \times AG = (2X) \times 0.8 + X \times 2.4$	M1 A2 **ft** (1,0)
	$AG = \dfrac{4}{3}$ (m), 1.3, 1.33,...	A1 **(4)**
		[7]

Question Number	Scheme	Marks
3.		
	(a) $\perp$ plane $\qquad R = 20\cos 60° + 5g\cos 30°$	M1 A2(1,0)
	$\qquad\qquad\qquad\quad = 52.4\ (\text{N})$ $\qquad\qquad$ or 52	A1 **(4)**
	(b) $\qquad\qquad\qquad\qquad F_r = \mu R$	B1
	$\qquad$ □ plane $\qquad F + 20\cos 30° = 5g\cos 60°$	M1 A2(1, 0)
	$\qquad\qquad$ Leading to $\mu = 0.137$ $\qquad$ or 0.14	A1 **(5)**
		[9]
4.	(a)	B1 B1 20, 8, 25 B1 **(3)**
(b)	$v = u + at \implies 8 = 20 - 0.4t$	M1
	$\qquad\qquad\qquad t = 30\ (\text{s})$	A1 **(2)**
(c)	$1960 = (25 \times 20) + (30 \times 8) + (\frac{1}{2} \times 30 \times 12) + (60 \times 8) + 8 \times t + \frac{1}{2} \times t \times 12$	M1A3 **ft** (2 ,1, 0)
	$1960 = 500 + 240 + 180 + 480 + 14t$	DM1 A1
	$T = 115 + 40$	DM1
	$\quad = 155$	A1 **(8)**
		[13]

Question Number	Scheme	Marks
5.	(a) $v^2 = u^2 + 2as \implies 28^2 = u^2 + 2 \times 9.8 \times 17.5$ Leading to $u = 21$ $\ast$ cso	M1 A1 A1 **(3)**
	(b) $s = ut + \dfrac{1}{2}at^2 \implies 19 = 21t - 4.9t^2$ $4.9t^2 - 21t + 19 = 0$ $t = \dfrac{21 \pm \sqrt{21^2 - 4 \text{x} 4.9 \text{.} \text{x} 19}}{9.8}$ $t = 2.99$ or 3.0 $t = 1.30$ or 1.3	M1 A1 DM1 A1 A1 **(5)**
	(c) N2L $4g - 5000 = 4a$ $(a = -1240.2)$ $v^2 = u^2 + 2as \implies 0^2 = 28^2 - 2 \times 1240.2 \times s$ Leading to $s = 0.316$ (m) or 0.32	M1 A1 M1 A1 **(4)** **[12]**
6.	(a) $\arctan \dfrac{7.5}{12} = 32°$ Bearing is 302 (allow more accuracy)	M1 A1 A1 **(3)**
	(b) $\mathbf{s} = 40\mathbf{i} - 6\mathbf{j} + t(-12\mathbf{i} + 7.5\mathbf{j})$	M1 A1 **(2)**

	(c) $t = 3$, $\mathbf{s} = 4\mathbf{i} + 16.5\mathbf{j}$
	                   $\mathbf{s} - \mathbf{b} = -3\mathbf{i} + 4\mathbf{j}$
	             $SB = \sqrt{\left((-3)^2 + 4^2\right)} = 5$ (km)
		M1
		 M1
		 DM1 A1 **(4)**

	(d) Equating **i** components
	            $40 - 12t = 7$ **or** $-33 + 12t = 0$
	
	                     $t = 2\dfrac{3}{4}$
	
	 When $t = 2\dfrac{3}{4}$, $\mathbf{s} = (7\mathbf{i}) + 14\dfrac{5}{8}\mathbf{j}$
	
	            $SB = 2\dfrac{1}{8}$ (km) 2.125, 2.13
		M1
		
		 A1
		
		 M1
		
		 A1 **(4)**
		 [13]

Question Number	Scheme	Marks
7.		
	(a) For system N2L $\quad 4-3=0.8a$	M1 A1
	$\qquad\qquad a=1.25 \ \left(\mathrm{m\,s^{-2}}\right),\ 1.3$	A1 **(3)**
	(b) $\qquad v=u+at \implies v=0+1.25\times6=7.5 \ \left(\mathrm{m\,s^{-1}}\right)$	M1 A1 **(2)**
	(c) For $P\quad$ N2L $\quad T-1=0.3\times1.25 \qquad\qquad\qquad$ ft their a	M1 A1ft
	$\qquad\qquad T=1.375 \ \left(\mathrm{N}\right) \ 1.38,\ 1.4$	A1 **(3)**
	OR For $Q\quad$ N2L $\quad 4 - 2 - T = 0.5 \text{ x } 1.25$	
	(d) For system N2L $\qquad -3=0.8a \implies a=-3.75$	M1 A1
	$\qquad v^2=u^2+2as \implies 0^2=7.5^2-2\times3.75s$	M1
	$\qquad\qquad\qquad s=7.5 \ \left(\mathrm{m}\right)$	A1 **(4)**
	(e) For $P\quad$ N2L $\qquad T'+1=0.3\times3.75$	M1 A1
	$\qquad\qquad T'=0.125 \ \left(\mathrm{N}\right),\ 0.13$	A1 **(3)**
		[15]