Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Advanced Subsidiary

Friday 11 January 2008 – Morning

Time: 1 hour 30 minutes

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

Write your centre number, candidate number, your surname, initials 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.
The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 7 questions on this 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 gain no credit.

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1. Two particles A and B have masses 4 kg and m kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is 5 m s^{-1} and the speed of B is 3 m s^{-1}. Immediately after the collision, the direction of motion of A is unchanged and the speed of A is 1 m s^{-1}.

(*a*) Find the magnitude of the impulse exerted on A in the collision.

(2)

Immediately after the collision, the speed of B is 2 m s^{-1}.

(*b*) Find the value of m.

(4)

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2. A firework rocket starts from rest at ground level and moves vertically. In the first 3 s of its motion, the rocket rises 27 m. The rocket is modelled as a particle moving with constant acceleration a m s^{-2}. Find

(*a*) the value of a,

(2)

(*b*) the speed of the rocket 3 s after it has left the ground.

(2)

After 3 s, the rocket burns out. The motion of the rocket is now modelled as that of a particle moving freely under gravity.

(*c*) Find the height of the rocket above the ground 5 s after it has left the ground.

(4)

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3. A car moves along a horizontal straight road, passing two points A and B. At A the speed of the car is 15 m s^{-1}. When the driver passes A, he sees a warning sign W ahead of him, 120 m away. He immediately applies the brakes and the car decelerates with uniform deceleration, reaching W with speed 5 m s^{-1}. At W, the driver sees that the road is clear. He then immediately accelerates the car with uniform acceleration for 16 s to reach a speed of V m s^{-1} ($V > 15$). He then maintains the car at a constant speed of V m s^{-1}. Moving at this constant speed, the car passes B after a further 22 s.

(*a*) Sketch, in the space below, a speed-time graph to illustrate the motion of the car as it moves from A to B.

(3)

(*b*) Find the time taken for the car to move from A to B.

(3)

The distance from A to B is 1 km.

(*c*) Find the value of V.

(5)

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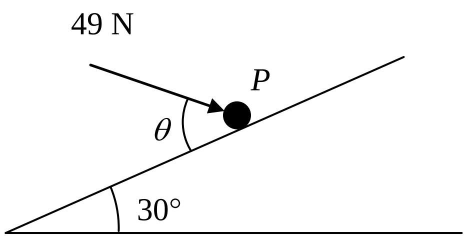
4. **Figure 1**



A particle P of mass 6 kg lies on the surface of a smooth plane. The plane is inclined at an angle of 30° to the horizontal. The particle is held in equilibrium by a force of magnitude 49 N, acting at an angle θ to the plane, as shown in Figure 1. The force acts in a vertical plane through a line of greatest slope of the plane.

(*a*) Show that $\cos\theta = \frac{3}{5}$.

(3)

(*b*) Find the normal reaction between P and the plane.

(4)

The direction of the force of magnitude 49 N is now changed. It is now applied horizontally to P so that P moves up the plane. The force again acts in a vertical plane through a line of greatest slope of the plane.

(*c*) Find the initial acceleration of P.

(4)

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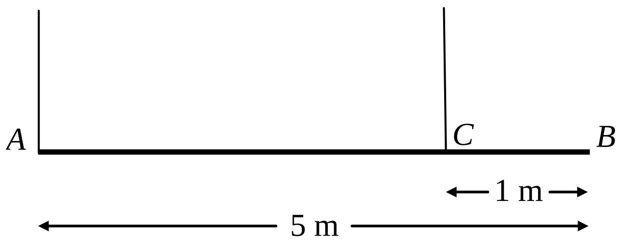
5. **Figure 2**



A beam *AB* has mass 12 kg and length 5 m. It is held in equilibrium in a horizontal position by two vertical ropes attached to the beam. One rope is attached to *A*, the other to the point *C* on the beam, where *BC* = 1 m, as shown in Figure 2. The beam is modelled as a uniform rod, and the ropes as light strings.

(*a*) Find

(i) the tension in the rope at *C*,

(ii) the tension in the rope at *A*.

(5)

A small load of mass 16 kg is attached to the beam at a point which is *y* metres from *A*. The load is modelled as a particle. Given that the beam remains in equilibrium in a horizontal position,

(*b*) find, in terms of *y*, an expression for the tension in the rope at *C*.

(3)

The rope at *C* will break if its tension exceeds 98 N. The rope at *A* cannot break.

(*c*) Find the range of possible positions on the beam where the load can be attached without the rope at *C* breaking.

(3)

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6. [*In this question, the unit vectors* **i** *and* **j** *are due east and due north respectively.*]

A particle P is moving with constant velocity $(-5\mathbf{i} + 8\mathbf{j})$ m s^{-1}. Find

(*a*) the speed of P,

(2)

(*b*) the direction of motion of P, giving your answer as a bearing.

(3)

At time $t = 0$, P is at the point A with position vector $(7\mathbf{i} - 10\mathbf{j})$ m relative to a fixed origin O. When $t = 3$ s, the velocity of P changes and it moves with velocity $(u\mathbf{i} + v\mathbf{j})$ m s^{-1}, where u and v are constants. After a further 4 s, it passes through O and continues to move with velocity $(u\mathbf{i} + v\mathbf{j})$ m s^{-1}.

(*c*) Find the values of u and v.

(5)

(*d*) Find the total time taken for P to move from A to a position which is due south of A.

(3)

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7. **Figure 3**

Two particles A and B, of mass m and $2m$ respectively, are attached to the ends of a light inextensible string. The particle A lies on a rough horizontal table. The string passes over a small smooth pulley P fixed on the edge of the table. The particle B hangs freely below the pulley, as shown in Figure 3. The coefficient of friction between A and the table is μ. The particles are released from rest with the string taut. Immediately after release, the magnitude of the acceleration of A and B is $\frac{4}{9}g$. By writing down separate equations of motion for A and B,

(*a*) find the tension in the string immediately after the particles begin to move,

(3)

(*b*) show that $\mu = \frac{2}{3}$.

(5)

When B has fallen a distance h, it hits the ground and does not rebound. Particle A is then a distance $\frac{1}{3}h$ from P.

(*c*) Find the speed of A as it reaches P.

(6)

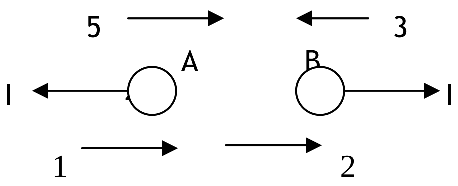
(*d*) State how you have used the information that the string is light.

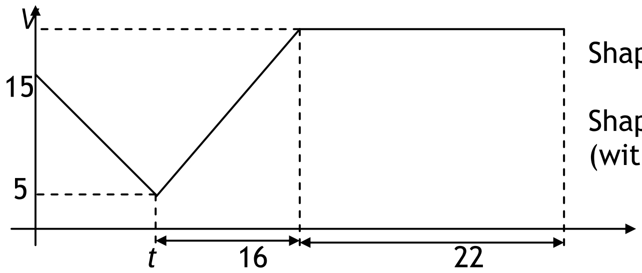
(1)

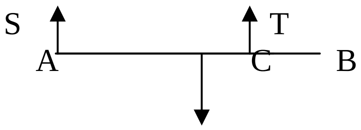
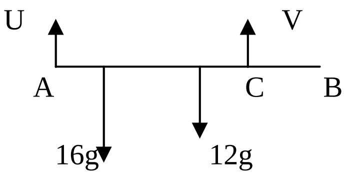
TOTAL FOR PAPER: 75 MARKS

END

January 2008
6677 Mechanics 1 Mathematics
Mark Scheme

Question Number	Scheme	Marks
1(a)	. 	
	$I = 4(5 - 1) = \underline{16 \text{ Ns}}$	M1 A1 (2)
(b)	CLM: $4 \times 5 - m \times 3 = 4 \times 1 + m \times 2$	M1 A1
	$\Rightarrow m = \underline{3.2}$	DM1 A1 (4)
	or	**or**
	$16 = m(3 + 2)$	M1 A1
	$\Rightarrow m = \underline{3.2}$	DM1 A1 (4) **6**
2.(a)	$27 = 0 + ½.a.3^2 \Rightarrow a = \underline{6}$	M1 A1 (2)
(b)	$v = 6 \times 3 = \underline{18 \text{ m s}^{-1}}$	M1 A1 f.t. (2)
(c)	From $t = 3$ to $t = 5$, $s = 18 \times 2 - ½ \times 9.8 \times 2^2$	M1 A1 f.t.
	Total ht. = $s + 27 = \underline{43.4 \text{ m}, 43 \text{ m}}$	M1 A1 (4)
		8

Question Number	Scheme	Marks
3.(a)	 Shape 'V'	B1
	Shape for last 22s (with V > 15)	B1
	Figures	B1 (3)
(b)	½(15 + 5) x t = 120	M1
	$\Rightarrow$ t = 12 $\rightarrow$ T = 12 + 16 + 22 = <u>50 s</u>	M1 A1 (3)
(c)	120 + ½(V + 5).16 + 22V = 1000	M1 B1 A1
	Solve: 30V = 840 $\Rightarrow$ V = <u>28</u>	DM1 A1 (5)
		11
4.(a)	R (// plane): 49 cos θ = 6g sin 30	M1 A1
	$\Rightarrow$ cos θ = 3/5 *	A1 (3)
(b)	R (perp to plane): R = 6g cos 30 + 49 sin θ	M1 A1
	R ≈ <u>90.1 or 90 N</u>	DM1 A1 (4)
(c)	R (// to plane): 49 cos 30 – 6g sin 30 = 6a	M1 A2,1,0
	$\Rightarrow$ a ≈ 2.17 or 2.2 m s^{-2}	A1 (4)
		11

Question Number	Scheme	Marks
5.(a)		
	M(A): T x 4 = 12g x 2.5	M1 A1
	T = <u>7.5g or 73.5 N</u>	A1
	R(↑) $S + T = 12g$	M1
	⇒ S = <u>4.5g or 44.1 N</u>	A1 (5)
(b)		
	M(A) V x 4 = 16g x y + 12g x 2.5	M1 A1
	V = <u>4gy + 7.5g or 39.2y + 73.5 N</u>	A1 (3)
(c)	$V \le 98 \Rightarrow 39.2y + 73.5 \le 98$	M1
	$\Rightarrow y \le 0.625 = 5/8$	DM1
	Hence "load must be no more than 5/8 m from A" (o.e.)	A1 (3)
		11
6.(a)	Speed = $\sqrt{(5^2 + 8^2)} \approx$ <u>9.43 m s^{-1}</u>	M1 A1 (2)
(b)	Forming arctan 8/5 or arctan 5/8 oe	M1
	Bearing = 360 – arctan 5/8 or 270 + arctan 8/5 = <u>328</u>	DM1 A1 (3)
(c)	At t = 3, p.v. of P = (7 – 15)**i** + (–10 + 24)**j** = –8**i** + 14**j**	M1 A1
	Hence –8**i** + 14**j** + 4(u**i** + v **j**) = **0**	M1
	⇒ <u>u = 2, v = – 3.5</u>	DM1 A1 (5)
(d)	p.v. of P t secs after changing course = (–8**i** + 14**j**) + t(2**i** – 3.5**j**)	M1
	= 7**i** + …..	DM1
	Hence total time = <u>10.5 s</u>	A1 (3)
		13

Question Number	Scheme	Marks
7.(a)	B: $2mg - T = 2m \times 4g/9$	M1 A1
	$\Rightarrow T = \underline{10mg/9}$	A1 (3)
(b)	A: $T - \mu mg = m \times 4g/9$	M1 B1 A1
	Sub for T and solve: $\mu = 2/3$ *	DM1 A1 (5)
(c)	When B hits: $v^2 = 2 \times 4g/9 \times h$	M1 A1
	Deceleration of A after B hits: $ma = \mu mg \Rightarrow a = 2g/3$	M1 A1 f.t.
	Speed of A at P: $V^2 = 8gh/9 - 2 \times 2g/3 \times h/3$	DM1
	$\Rightarrow V = \frac{2}{3}\sqrt{(gh)}$	A1 (6)
(d)	Same tension on A and B	B1 (1)
		15