WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Subsidiary/Advanced

WJEC
CBAC

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch Gyfrannol/Uwch

981/01

**MATHEMATICS M2**

**Mechanics 2**

P.M. WEDNESDAY, 22 June 2005

($1\frac{1}{2}$ hours)

# NEW SPECIFICATION

## ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a 12 page answer book;
- a Formula Booklet;
- a calculator.

## INSTRUCTIONS TO CANDIDATES

Answer **all** questions.

Take $g$ as 9·8 ms $^{-2}$.

## INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

You are reminded of the necessity for good English and orderly presentation in your answers.

**1.** One end of a light elastic string, of natural length 0·8 m, is attached to a fixed point $O$, and the other end is attached to a particle of mass 5 kg. When the particle hangs in equilibrium vertically below $O$, the length of the string is 1·3 m.

*(a)* Calculate the modulus of elasticity of the string. [3]

*(b)* Determine the elastic energy stored in the string. [2]

**2.** A particle moves in a straight line such that its acceleration $a$ ms$^{-2}$ is given by

$$a = 4 - 6t \quad \text{for} \quad t \geqslant 0.$$

At time $t = 0$, the particle is at the point $O$ and its velocity is 4 ms$^{-1}$.

*(a)* Find an expression for the velocity of the particle at time $t$ s. [3]

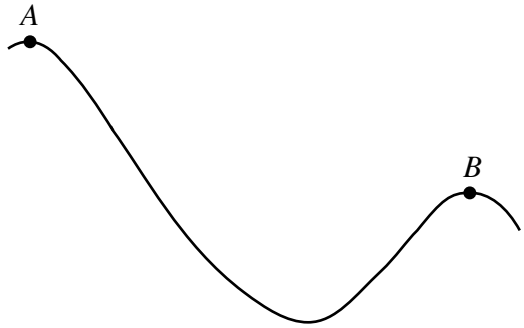
*(b)* Find an expression for the displacement of the particle from $O$ at time $t$ s. [3]

*(c)* Determine the time when the particle comes to rest instantaneously and the distance of the particle from $O$ at this time. [3]

*(d)* Calculate the **speed** of the particle when $t = 3$, and determine whether or not the **speed** of the particle is increasing or decreasing at this time. [3]

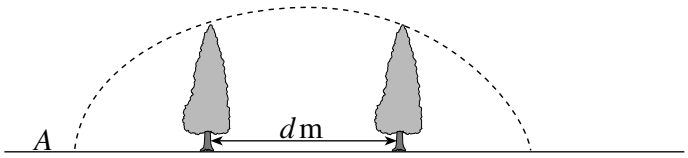
**3.** A car, of mass 1250 kg, is travelling up a hill inclined at an angle $\alpha$ to the horizontal at a constant speed of 7·5 ms$^{-1}$. The car's engine is working at a rate of 30 kW and the resistance to motion of the car is 1550 N. Find the value of $\alpha$, giving your answer in degrees correct to one decimal place. [6]

**4.** The diagram shows two points $A$ and $B$ on a roller coaster ride in an amusement park.




The heights of $A$ and $B$ above ground level are 30 m and 22 m respectively. The length of the track between $A$ and $B$ is 88 m. The resistance to motion of the carriage may be assumed to have a constant magnitude of 132 N. A carriage, of total mass 240 kg, has speed 2 ms$^{-1}$ at $A$. Calculate the speed of the carriage at $B$. [8]

**5.** A golfer hits a ball from the point $A$ with initial velocity $24{\cdot}5\,\text{ms}^{-1}$ at an angle $\alpha$ above the horizontal, where $\sin\alpha = 0{\cdot}8$. The ball just clears the tops of two trees. The tops of the trees are both $14{\cdot}7$ m above the level of $A$ and are a horizontal distance $d$ m apart.




*(a)* (i) Find the time taken for the ball to reach the top of the first tree.

(ii) Determine the value of $d$. [8]

*(b)* Find the magnitude and direction of the velocity of the ball $0{\cdot}75$ s after it was hit. [6]

**6.** At time $t$ s, a particle $P$ has position vector $\mathbf{r}$ m with respect to an origin $O$ given by

$$\mathbf{r} = (2t - 5)\mathbf{i} + (t - 3)\mathbf{j} + (7 - 2t)\mathbf{k}.$$

*(a)* Show that the distance of the particle from the origin at time $t$ s is given by

$$OP^2 = 9t^2 - 54t + 83,$$

and find the value of $t$ when $P$ is closest to $O$. [5]

*(b)* Find the velocity of $P$ and determine its magnitude. [3]

*(c)* Show that, when $P$ is closest to $O$, the direction of the velocity of $P$ is perpendicular to the line $OP$. [3]

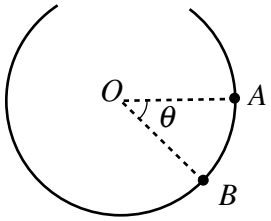
**7.** A rider on a motorcycle is travelling at a constant speed of $42\,\text{ms}^{-1}$ in a horizontal circle on a track banked at an angle of 25° to the horizontal. There is no tendency to sideslip at this speed. The total mass of the motorcycle and the rider is 600 kg.
Modelling the motorcycle and the rider as a particle,

*(a)* calculate the normal reaction of the track on the motorcycle, [3]

*(b)* determine the radius of the circle. [4]

**TURN OVER.**

**8.** A marble, of mass 0·3 kg, moves on the inner surface of a spherical bowl of radius 0·4 m. Initially, the marble is held at $A$, on the inner surface of the bowl, where $OA$ is horizontal, as shown in the diagram.




The marble is then projected with a speed of 2 ms$^{-1}$ vertically downwards. When the marble is at the point $B$, $\hat{AOB} = \theta$.

*(a)* Find, in terms of $\theta$, an expression for $v^2$, where $v$ ms$^{-1}$ is the speed of the marble at $B$. [4]

*(b)* Show that the reaction $R$ N of the surface of the bowl on the marble is given by

$$R = 3 + 8{\cdot}82 \sin\theta \ .$$ [4]

*(c)* Find the greatest possible value of $\theta$, and briefly describe the subsequent motion of the marble. [4]