



**GCE A LEVEL**

**1300U40-1**

**TUESDAY, 21 JUNE 2022 – AFTERNOON**

**MATHEMATICS – A2 unit 4**

**APPLIED MATHEMATICS B**

**1 hour 45 minutes plus your additional time allowance**

## **ADDITIONAL MATERIALS**

**In addition to this examination paper, you will need:**

- a WJEC pink 16-page answer booklet;
- a Formula Booklet;
- a calculator;
- statistical tables (RND/WJEC Publications).

## **INSTRUCTIONS TO CANDIDATES**

**Use black ink, black ball-point pen or your usual method. You may use a pencil for graphs and diagrams only.**

**Answer ALL questions.**

**Write your answers in the separate answer booklet provided, following the instructions on the front of the answer booklet.**

**Use both sides of the paper. Please only write within the white areas of the booklet.**

**Write the question number in the left hand margin at the start of each answer. Write the sub parts, e.g. (a), (b) and (c), within the white areas of the booklet.**

**(Turn over)**

Leave at least two line spaces between each answer.

Take  $g$  as  $9.8 \text{ ms}^{-2}$

Sufficient working must be shown to demonstrate the MATHEMATICAL method employed.

Answers without working may not gain full credit.

Unless the degree of accuracy is stated in the question, answers should be rounded appropriately.

### INFORMATION FOR CANDIDATES

The maximum mark for this paper is **80**.

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.

(Turn over)

**REMINDER: Sufficient working must be shown to demonstrate the MATHEMATICAL method employed.**

**SECTION A: STATISTICS**

01. An interview process involves three stages of selection. The first stage involves completing an aptitude test. The scores in the aptitude test are on a continuous scale and normally distributed with mean **66** and standard deviation **14**. Candidates achieving the highest **5%** of scores in the aptitude test progress immediately to the third stage of the interview process. Candidates achieving the lowest **5%** of scores in the aptitude test do not progress any further in the interview process.

Ffion progresses to the second stage of the interview process. Find the range of possible scores that Ffion obtained in the aptitude test.

**[3 marks]**

**(Turn over)**

It is known that:

$$P(F1 | C) = 0.70 \quad P(F1 | G) = 0.30 \quad P(F1 | N) = 0.00$$

$$P(F2 | C) = 0.20 \quad P(F2 | G) = 0.05 \quad P(F2 | N) = 0.85$$

$$P(F3 | C) = 0.10 \quad P(F3 | G) = 0.65 \quad P(F3 | N) = 0.15$$

02. System faults that occur in a particular type of aeroplane can be categorised in one of three mutually exclusive ways as compass (event **C**), gyroscopic (event **G**) or navigational (event **N**)

It has been established that, when a fault occurs,

$$P(C) = 0.4 \quad P(G) = 0.35$$

$$\text{and } P(N) = 0.25$$

When a fault occurs, the cockpit shows one of three fault codes **F1**, **F2** or **F3**

You will need to use the probabilities on the page opposite to answer the questions below.

The cockpit is showing a fault code. Calculate the probability that this aeroplane

- (a) displays the fault code **F1** [2 marks]
- (b) has a compass fault, given that it displays the fault code **F1** [2 marks]
- (c) has a gyroscopic fault, given that it does not display the fault code **F2** [4 marks]

(Turn over)

03. Rectangles with perimeter **40 cm** are produced randomly. The length, in cm, of the shorter side,  **$X$** , is uniformly distributed across all possible values of  **$X$**

(a) State the mean and variance of  **$X$**  [3 marks]

(b) Find the probability that the area of a rectangle is greater than  **$96 \text{ cm}^2$**  [5 marks]

04. In a driving simulator, the stopping distances, in metres, for cars travelling at **20 mph** and **30 mph** can be modelled by normal distributions with means and standard deviations shown in the table below.

	STOPPING DISTANCE (METRES)	
TRAVELLING AT	MEAN	STANDARD DEVIATION
<b>20 mph</b>	<b>12</b>	<b>3.5</b>
<b>30 mph</b>	<b>23</b>	<b>3.8</b>

- (a) Calculate the probability that a car travelling at **30 mph** can stop within **30** metres.

[2 marks]

(Turn over)

04 (b)

Suppose an obstacle suddenly appears **20** metres away. Dafydd states that you are **50** times as likely to collide with the obstacle if you are travelling at **30 mph** as compared to **20 mph**

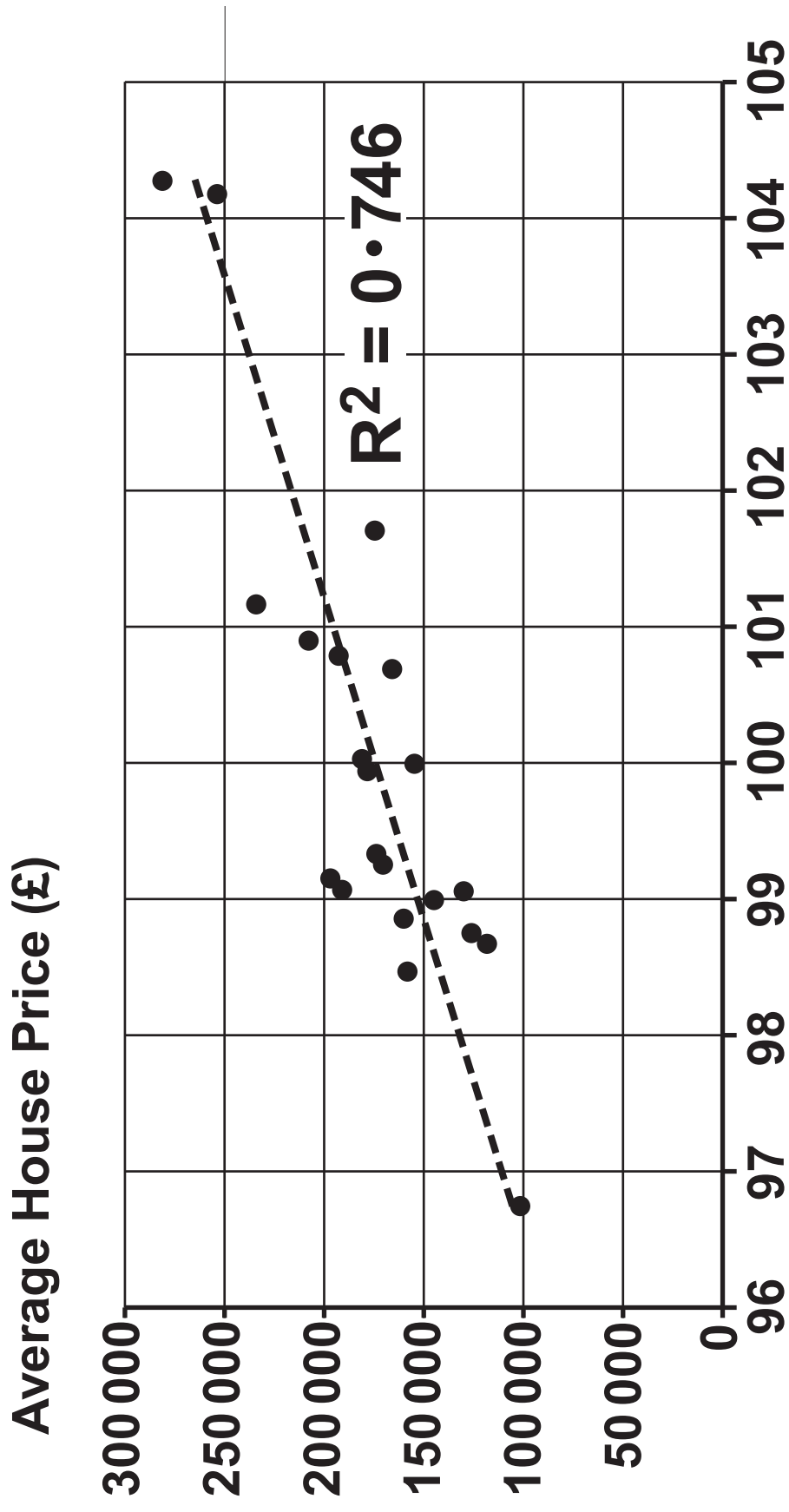
Check whether Dafydd is correct. [4 marks]

A campaigner for keeping the speed limit at **30 mph** rather than reducing it to **20 mph** in built-up areas claims that stopping distances are less than those stated above. He takes a random sample of **40** first-year university students and finds their mean stopping distance is **21.5** metres at **30 mph**

- (c) Test the campaigner's claim at the **1%** level of significance. [6 marks]
- (d) State a limitation to this test which calls into doubt the conclusion reached in part (c). [1 mark]

(Turn over)

# HOUSE PRICE VERSUS NATIONAL READING TEST SCORE



Average score in the National Reading Test

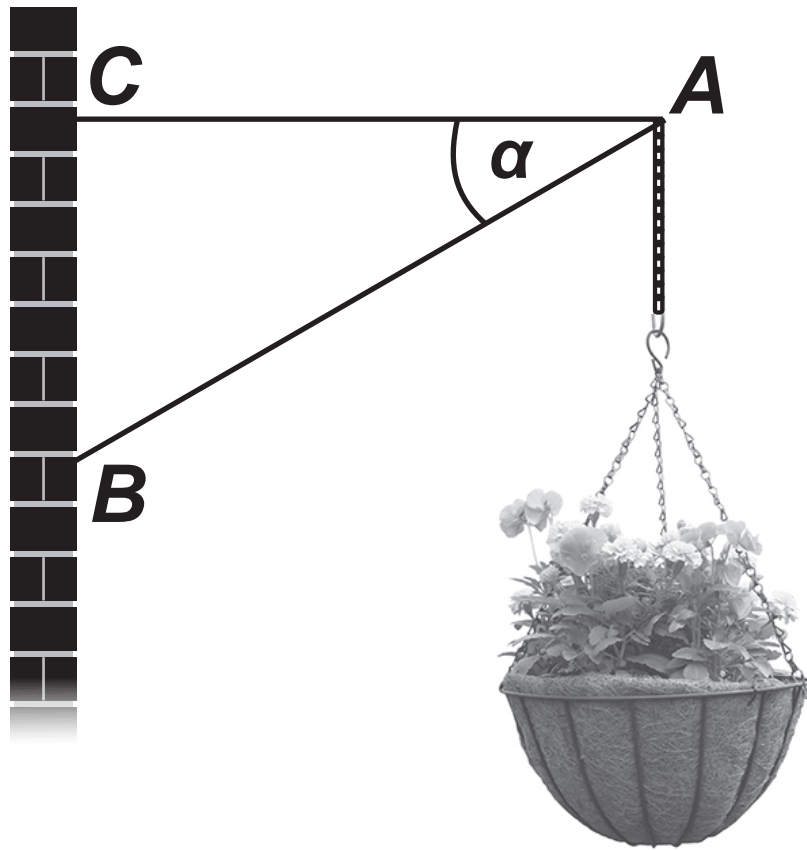
05. A government statistician wishes to investigate whether there is positive correlation between the variables **Average score in the National Reading Test** and **Average House Price**. She collects data on a randomly selected sample of **21** areas within Wales.

- (a) Carry out a **5%** significance test for correlation between the two variables, using the computer output opposite. [5 marks]

After seeing this output, the editor of a newspaper leads with the front-page headline,

**“Buy a more expensive house to boost your children’s reading ability!”**

- (b) Discuss whether the data support the headline. [2 marks]
- (c) Give a possible alternative explanation for this correlation. [1 mark]



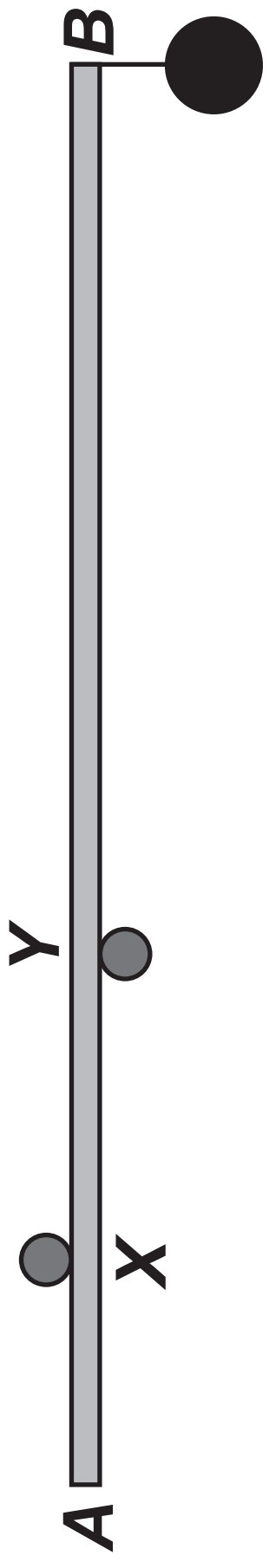
**SECTION B: DIFFERENTIAL EQUATIONS AND MECHANICS**

06. The diagram opposite shows a hanging basket attached at a point **A** to two light rods **AB** and **AC**

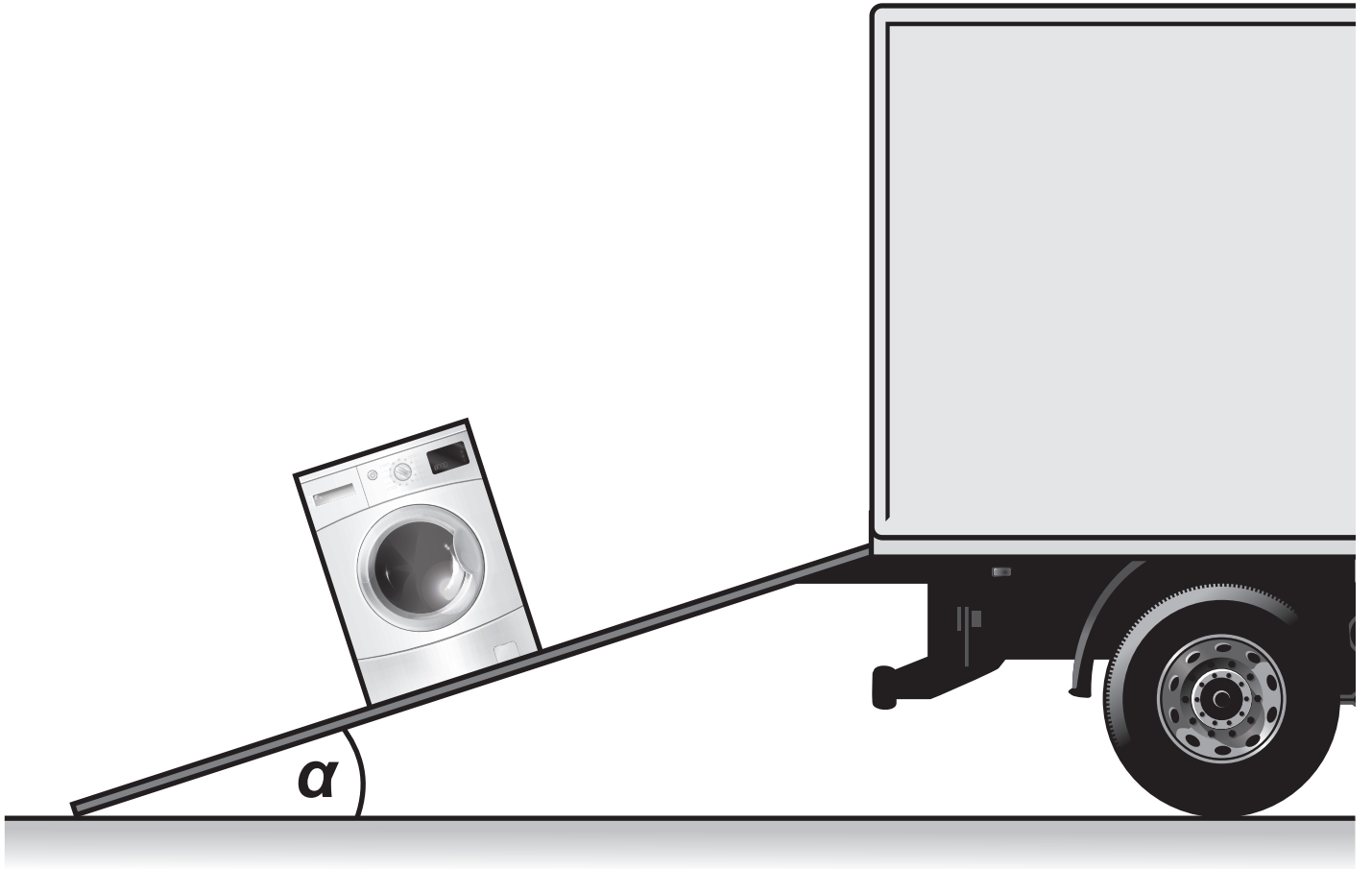
The rod **AC** is horizontal and the rod **AB** is inclined at an angle  $\alpha$  to the horizontal,

where  $\tan\alpha = \frac{3}{4}$

Given that the mass of the hanging basket is **3.6 kg**, calculate the thrust in the rod **AB** and the tension in the rod **AC** [5 marks]



07. The diagram opposite shows a uniform rod  $AB$  of length  $2.4\text{ m}$  and mass  $5\text{ kg}$ . The rod is held horizontally in equilibrium by means of two small, smooth, fixed cylindrical pegs at the points  $X$  and  $Y$  on the rod. The length of  $AX$  is  $0.4\text{ m}$  and the length of  $XY$  is  $0.5\text{ m}$ . An object of mass  $11\text{ kg}$  is attached to the rod at point  $B$ . The force exerted on the rod by each of the pegs is vertical.
- (a) Find the magnitude of each of the forces exerted on the rod by the pegs at the points  $X$  and  $Y$ . Give your answers in terms of  $g$  [7 marks]
- (b) An additional object of mass  $M\text{ kg}$  is attached at point  $A$  so that the rod is on the point of turning about  $Y$ . Calculate the value of  $M$  [3 marks]



08. The diagram opposite shows a ramp being used to load a washing machine of mass **90 kg** into a truck.

The washing machine may be modelled as a particle and the ramp as a rough plane inclined at an angle  $\alpha$  to the horizontal. The coefficient of friction between the plane and the washing

machine is  $\frac{2}{9}$

- (a) Suppose that the ramp is set up so that  $\alpha = 10^\circ$  and a rope is attached to the washing machine. When the rope is pulled with a constant force of **380 N** parallel to the line of greatest slope of the ramp, the washing machine moves up the ramp. Calculate the acceleration of the washing machine. [5 marks]
- (b) Suppose instead that, with the rope removed, the washing machine is at rest on the ramp. Calculate the maximum possible value of  $\alpha$  [3 marks]

(Turn over)

09. Megan wants to make some ice cubes. She fills a plastic ice cube tray with water of temperature  $10^{\circ}\text{C}$  and places it directly into the freezer. The temperature inside the freezer remains constant at  $-18^{\circ}\text{C}$

The temperature of the water at time  $t$  hours after being placed in the freezer is denoted by  $\theta^{\circ}\text{C}$

For Megan's scenario, Newton's law of cooling states that the rate of decrease of  $\theta$  is directly proportional to the difference between the temperature of the water and the temperature inside the freezer.

- (a) Using  $k$  as the constant of proportionality, where  $k$  is positive, write down a differential equation satisfied by  $\theta$  [1 mark]

09 (b)

Show that, for  $\theta > -18$

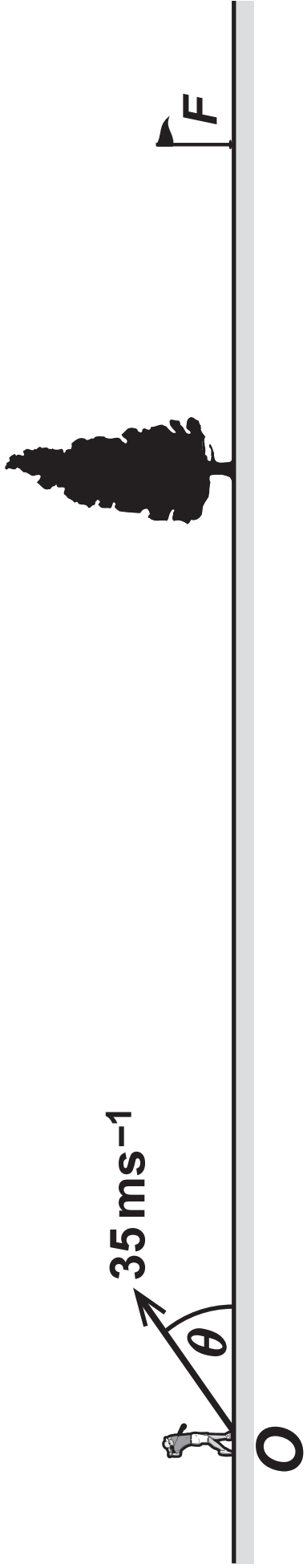
$$kt = \ln \left( \frac{28}{\theta + 18} \right)$$

[4 marks]

- (c) Given that the temperature of the water in the tray is  $6^{\circ}\text{C}$  after 1 hour, determine the total amount of time that Megan needs to wait for the temperature of the water to reach  $-5^{\circ}\text{C}$

Give your answer to the nearest hour. [3 marks]

(Turn over)



10. A golfer hits a ball towards a flag  $F$ , from a point  $O$ , with initial velocity of  $35 \text{ ms}^{-1}$  at an angle  $\theta$  above the horizontal as shown in the diagram opposite.

During its flight, the position vector of the golf ball relative to  $O$  is  $(x\mathbf{i} + y\mathbf{j})$  metres, where the unit vectors  $\mathbf{i}$  and  $\mathbf{j}$  are horizontal and vertical respectively.

- (a) Show that, during the flight, the equation of the trajectory of the ball is given by

$$y = x \tan \theta - \frac{x^2}{250} (1 + \tan^2 \theta)$$

[4 marks]

10 (b)

The ball just clears the top of a tree. The top of the tree has position vector  $(100\mathbf{i} + 20\mathbf{j})$  m and the base of the flag has position vector  $(130\mathbf{j})$  m

- (i) Determine the two possible values of  $\tan \theta$
- (ii) Given that the ball lands short of the flag  $F$  find the shortest possible distance of the ball from the base of the flag when it first hits the ground.  
[5 marks]

END OF PAPER