

## Problems

Time allowed: 4 hours.

NO calculators are to be used.

Questions 1 to 8 only require their numerical answers all of which are non-negative integers less than 1000.

Questions 9 and 10 require written solutions which may include proofs.

The bonus marks for the Investigation in Question 10 may be used to determine prize winners.

1. Two positive integers,  $a$  and  $b$ , satisfy the equation

$$\frac{2^a + 2^{2a} + 2^{2^a} + 2^{2^a}}{2024} = \frac{2^b}{23^b}.$$

Find the value of  $a + b$ .

[2 marks]

2. The area of a right-angled triangle is 120 and each of its three sides has integer length.

Find the length of its hypotenuse.

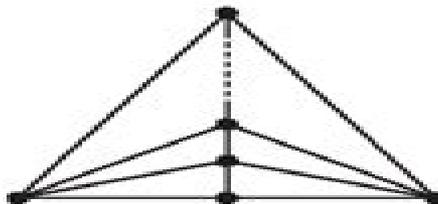
[2 marks]

3. Quadrilateral  $ABCD$  has perimeter 60 cm and  $AB$  has length 9 cm. Sides  $AD$  and  $BC$  are parallel with distance 7 cm between them. Points  $E$  and  $F$  are chosen on sides  $BC$  and  $AD$  respectively so that the line  $EF$  divides  $ABCD$  into two quadrilaterals with equal perimeters and equal areas.

What is the area of quadrilateral  $ABCD$ ?

[3 marks]

4. In the following figure, all the central dots are collinear and the bottom three dots are collinear. There are exactly 2024 triangles that have dots as vertices (no three collinear dots form a triangle).



How many dots are there?

[2 marks]

5. Three positive integers  $a$ ,  $b$ ,  $c$  satisfy

$$a^2 + b - c = 100 \quad (1)$$

$$a + b^2 - c = 124 \quad (2)$$

Find  $a + b + c$ .

[3 marks]

# Mathematics Olympiad Problems And Solutions

**IM Harris**



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