

# Eton College King's Scholarship Examination 2020

## SCIENCE 2 (Data Analysis)

(30 minutes)

Candidate Number: \_\_\_\_\_

**Remember to write your candidate number on every sheet in the space provided.**

*You should attempt ALL the questions. Write your answers in the spaces provided.*

*The maximum mark for each question or part of a question is shown in square brackets.*

*Calculators are allowed. In questions involving calculations, all your working must be shown.*

**Total Marks Available: 30**

For examiners' use only.

Total [30]	
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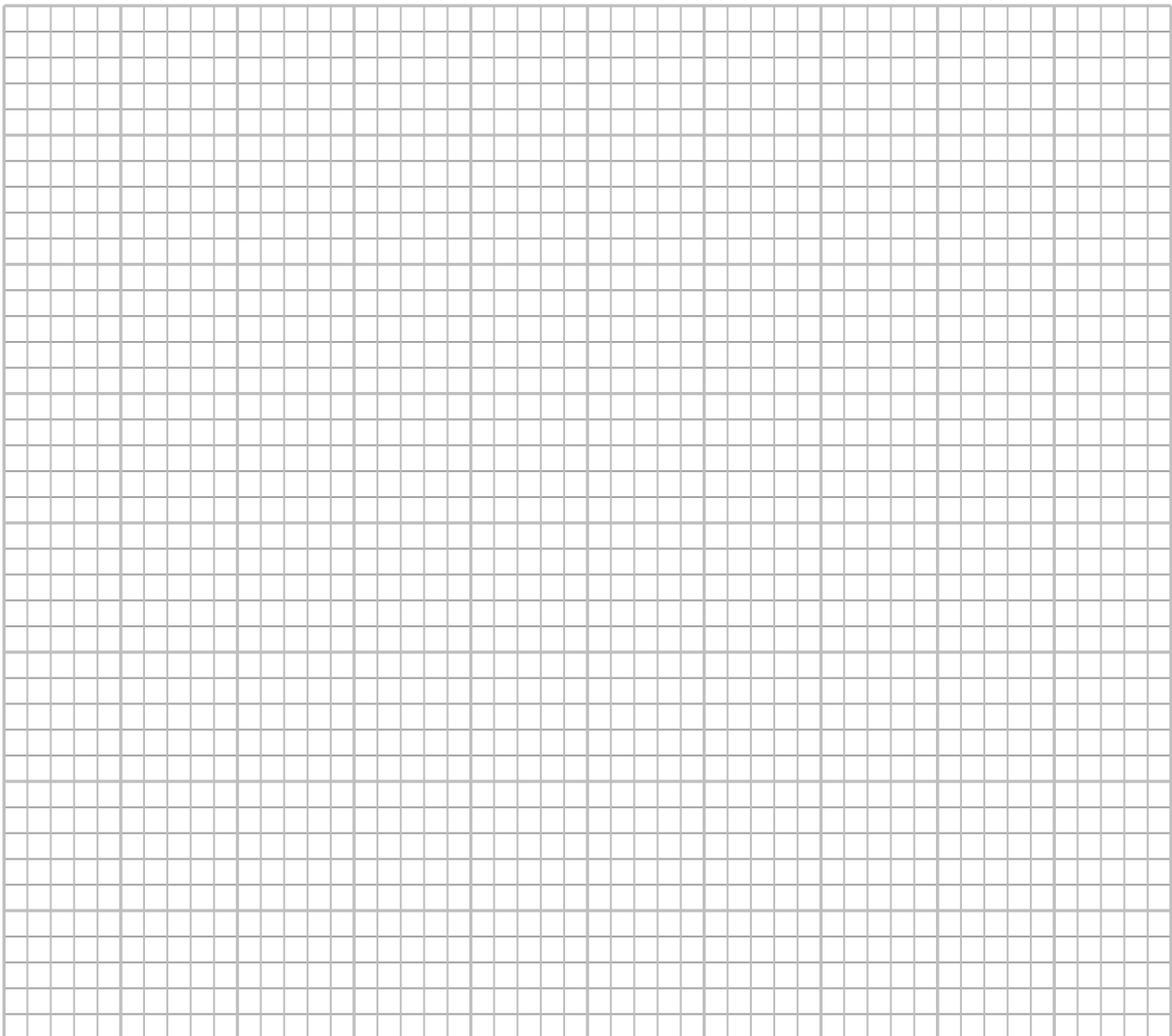
**Do not turn over until told to do so.**

1. This question is about springs and requires the use of Hooke’s Law:

$$F = kx$$

Here,  $F$  is the applied force on the spring,  $x$  is the extension of the spring and  $k$  is the ‘spring constant’. A student measures the length of the spring as he varies the force applied to it. Plot the following data on the grid below. Ensure the independent variable goes on the  $x$ -axis and include the origin. [5]

force / N	length / cm
1.5	14.3
3.0	19.5
4.2	22.5
6.0	28.5
7.0	28.0
9.0	36.0



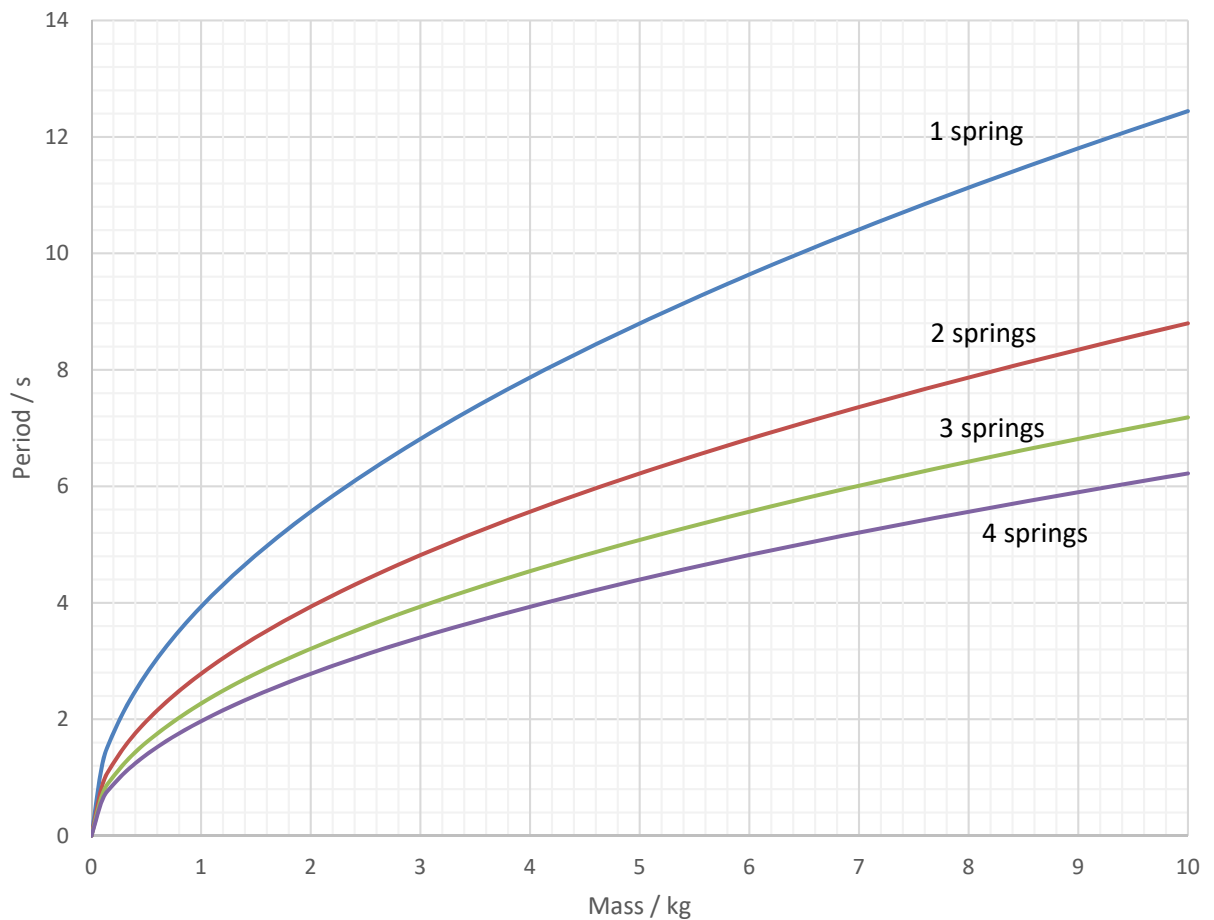
(a) From the graph, determine the original, unstretched length of the spring.

[2]

(b) Calculate the spring constant of the spring. Give your answer in units of N/m.

[4]

A different spring is used as a crude timekeeping device. A mass is hung from the spring; it is then pulled down and released. The mass oscillates (bounces) up and down with a certain time period  $T$ . The graph below shows how the period of oscillation  $T$  depends upon the mass  $m$  for different numbers of springs attached to the mass in *parallel* to each other. Note: all the springs are identical, each with spring constant  $k$ .





The system is used to determine when a 1 hour duration has passed by counting the appropriate number of oscillations, i.e. the number you calculated in the previous part. However, the true value of  $T$  can only be said to lie within 5% of the value that you have determined in part (d) (no measurement is ever perfect), and so the true duration will probably be slightly more or less than 1 hour.

- (f) Calculate the maximum and minimum values for the possible true duration. Give your answers in the format hh:mm:ss.

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[3]

As the spring-mass oscillates the amplitude of its oscillations decreases.

- (g) Explain, in terms of energy, what causes the amplitude of the oscillations to decrease.

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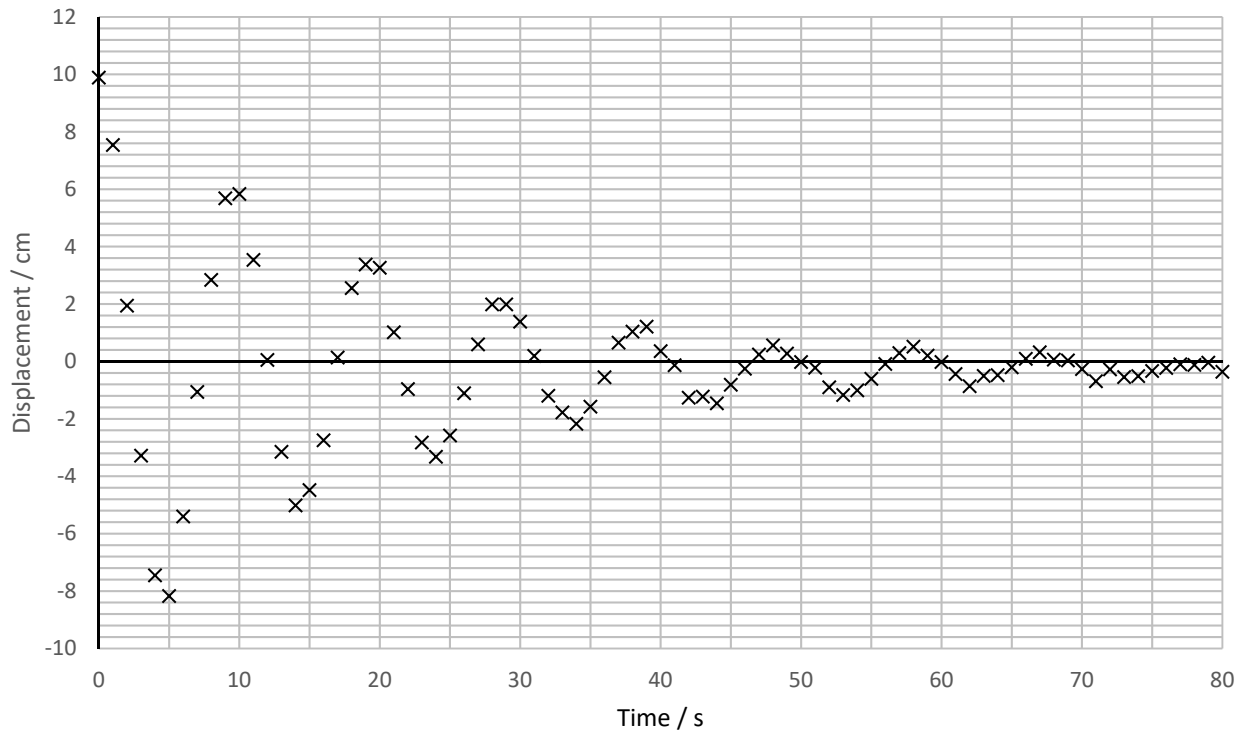
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[2]

The displacement of mass on the spring (i.e. how far it is above and below the equilibrium position) is measured as a function of time. The data is given below.



(h) Use the graph on the previous page to answer this part of the question.

- i. Draw an appropriate line through the data points. [1]
  
- ii. The amplitude of the oscillations take the same time to decrease by the same factor. By taking readings from the graph, determine the ‘half-life’ of the oscillations, i.e. how long it takes for the amplitude of the oscillations to halve.

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[2]

- iii. The initial amplitude was 10 cm. Calculate the amplitude if this system is allowed to run for 1 hour. Comment upon this value.

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[3]