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]	

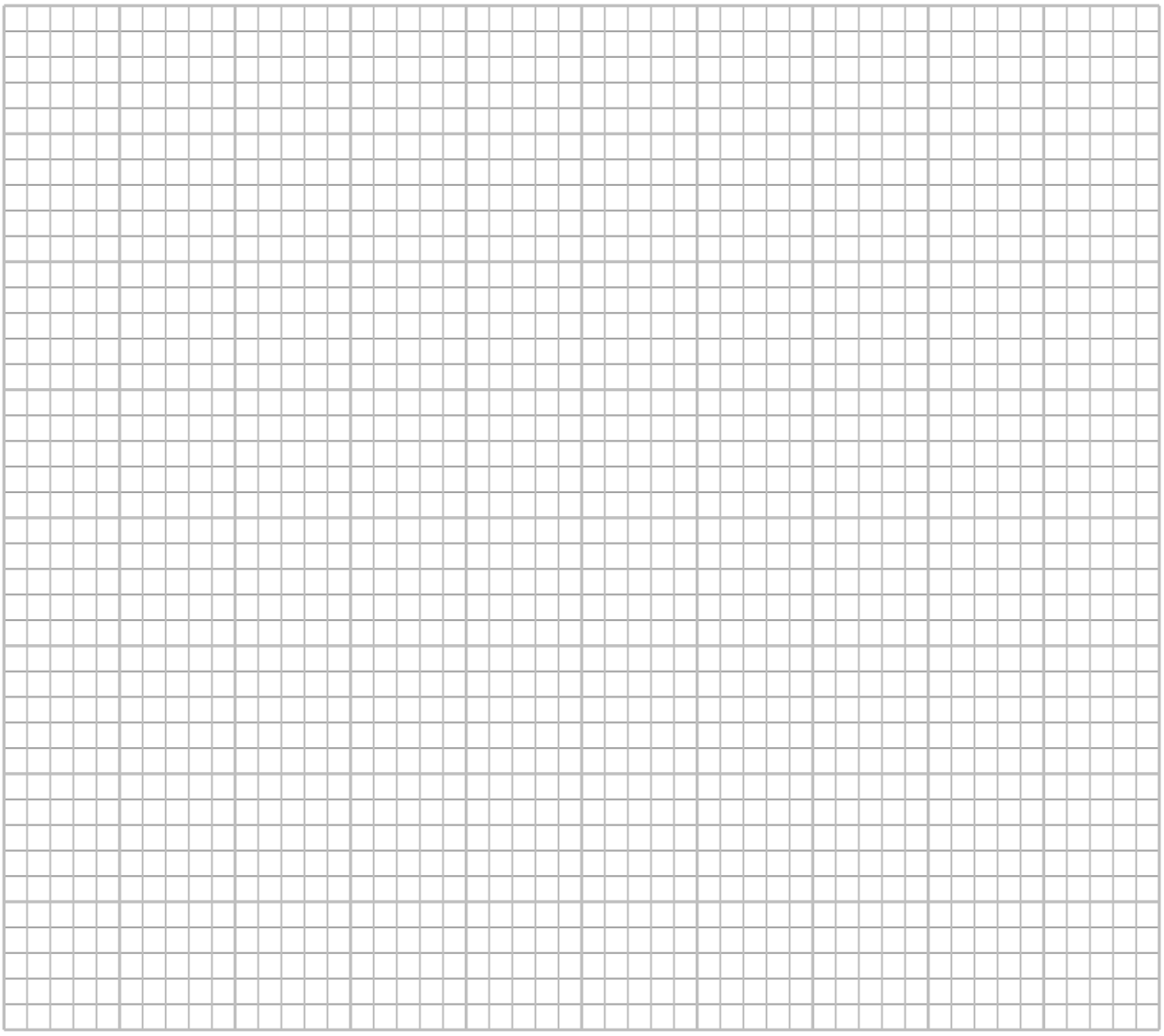
Do not turn over until told to do so.

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.

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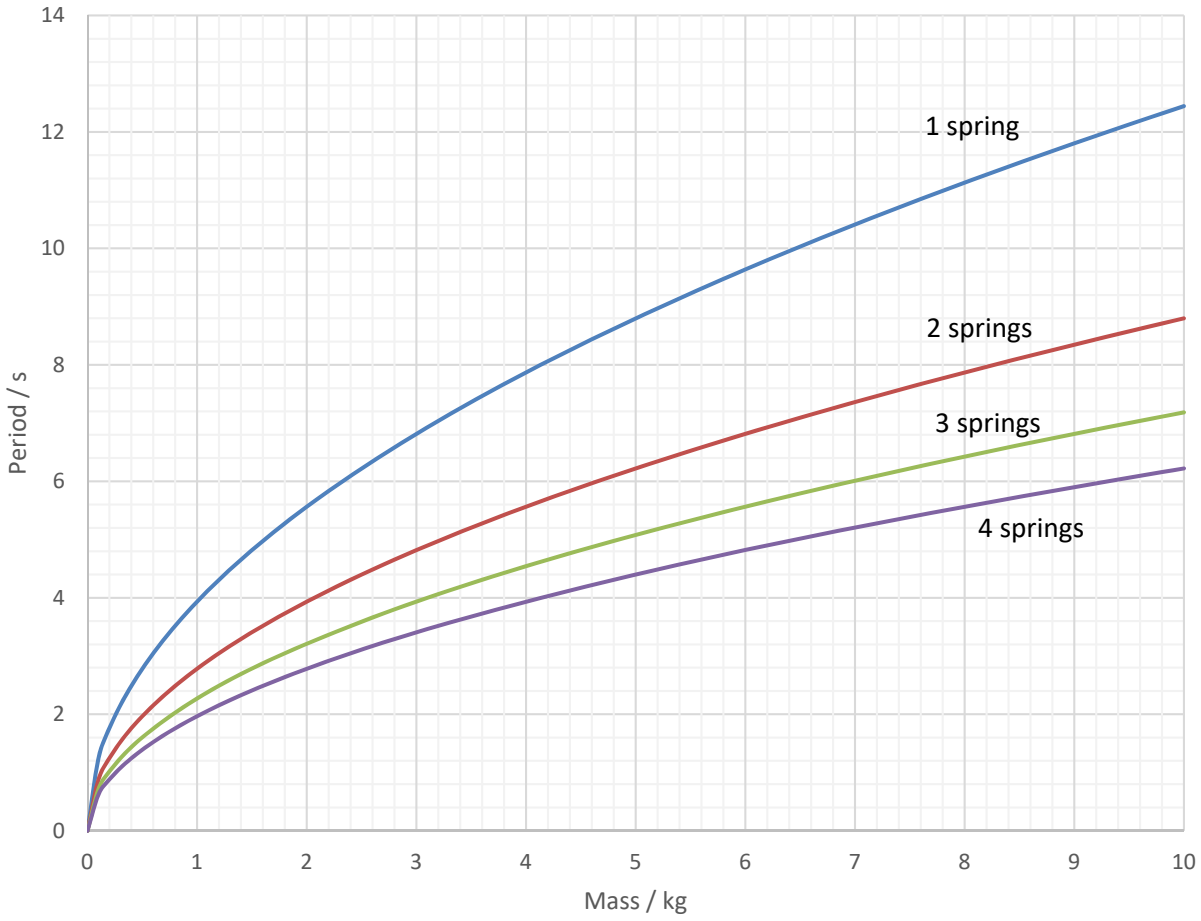
_____

_____ **[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.



(c) Circle the correct dependence of period on k and m, and justify your choice using data from the graph on page 3.

$T = 2\pi\sqrt{\frac{k}{m}}$ $T = 2\pi\sqrt{\frac{m}{k}}$ $T = 2\pi\sqrt{mk}$ $T = 2\pi\sqrt{\frac{1}{mk}}$

[4]

The mass m hanging off the spring is 6.0 kg.

(d) From the graph, determine the period of this spring-mass system. (Assume only one spring is used.)

[2]

(e) Calculate the number of oscillations that will pass during a 1 hour period. Give your answer to the nearest oscillation.

[2]

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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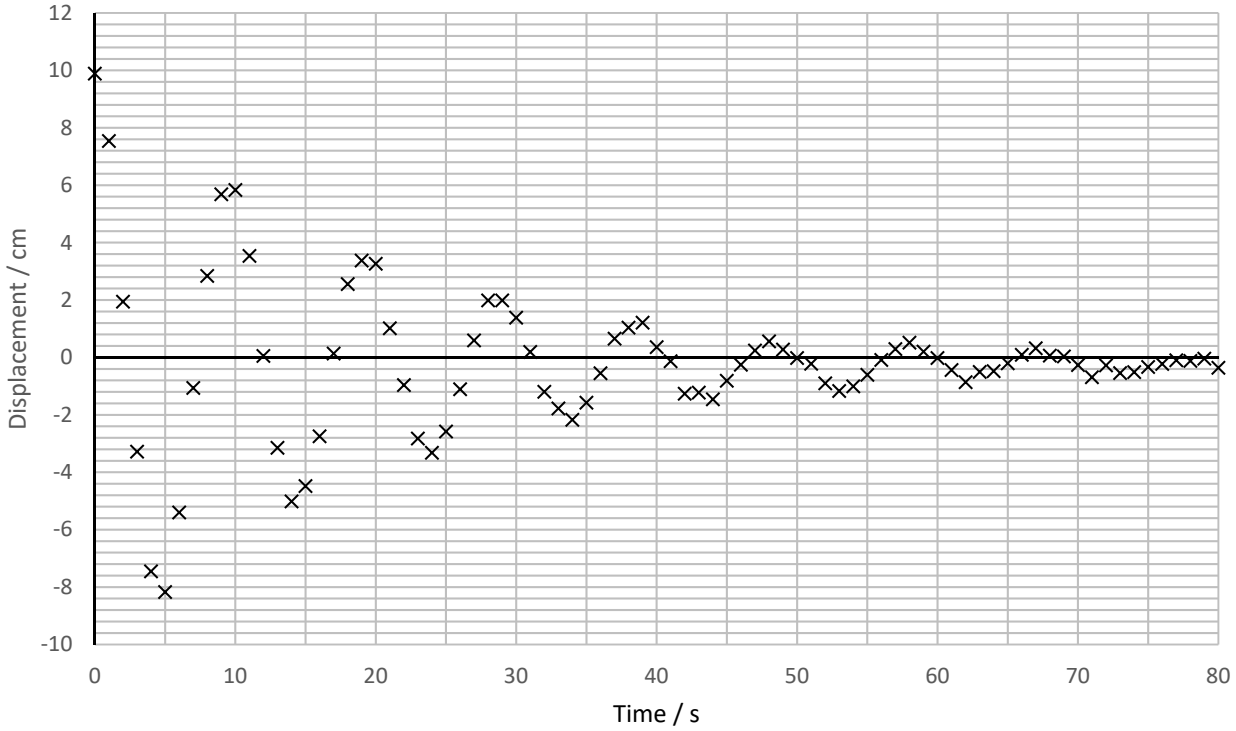
_____

_____

_____ **[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.

_____

_____

_____ **[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]**

[End of paper]