Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson BTEC Level 3 Nationals Diploma

Centre Number | Learner Registration Number

Wednesday 23 January 2019

Morning (Time: 50 minutes) | Paper Reference **31627H/1P**

Applied Science

Unit 5: Principles and Applications of Science II
Physics
SECTION C: THERMAL PHYSICS, MATERIALS AND FLUIDS

You must have:
A calculator and a ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and learner registration number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The exam comprises three papers worth 40 marks each.
  – Section A: Organs and systems (Biology)
  – Section B: Properties and uses of substances (Chemistry)
  – Section C: Thermal physics, materials and fluids (Physics)
- The total mark for this exam is 120.
- The marks for each question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- The formula sheet can be found at the back of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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Pearson

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A piston in an engine compresses gas in a cylinder and heats the gas.

The piston does work on the gas.

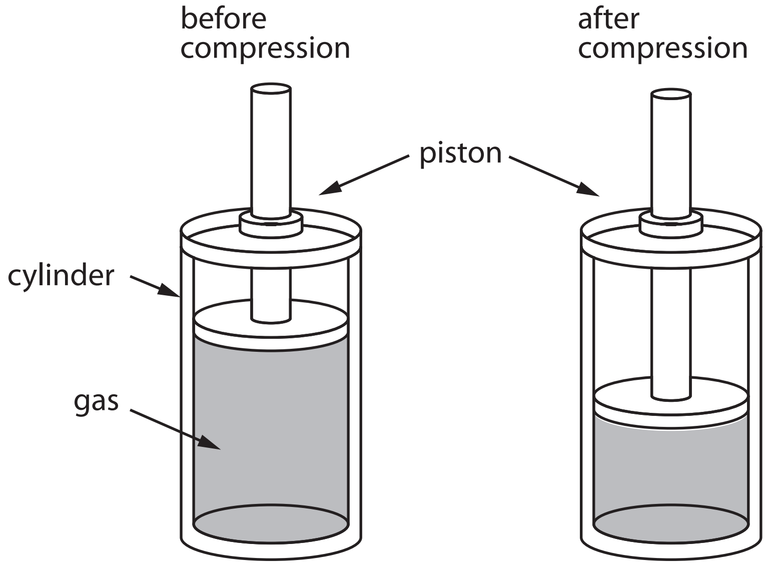

Figure 1

(a) Work done can be calculated using the equation $W = F\Delta x$

Identify what F stands for.

(1)

☐ **A** fatigue

☐ **B** fluid

☐ **C** force

☐ **D** fusion

(b) Give the meaning of the terms in the equation.

(2)

Δ

....

x

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(Total for Question 1 = 3 marks)

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2 Figure 2 shows an ice cube tray and a melting ice cube.

The ice cube takes a long time to melt.

This is because the ice cube has a high thermal capacity.

Figure 2

(a) Which is the correct unit for **thermal capacity**?

(1)

☒ **A** J kg K

☒ **B** J K

☒ **C** J K^{-1}

☒ **D** J kg^{-1} K^{-1}

(b) Explain how the motion and arrangement of the molecules in the ice cube change as it melts.

(4)

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(Total for Question 2 = 5 marks)

3 Steam engines are a type of heat engine.

The steam expands adiabatically in part of a steam engine.

(a) (i) Which **one** of these statements is correct for steam expanding adiabatically?

(1)

☒ **A** There is a change in temperature.

☒ **B** There is a change in the number of molecules.

☒ **C** There is no change in pressure.

☒ **D** There is no change in volume.

(ii) The steam engine obeys the second law of thermodynamics.

Explain how the steam engine obeys the second law.

(2)

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(b) Describe how a steam engine is an example of a heat engine.

(3)

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(c) (i) A boiler gives out 3.5×10^9 J of energy to heat a home each year.

To produce this amount of energy, the boiler takes in 2.9×10^{10} J.

(2)

Calculate the efficiency of the boiler.

Use the equation: efficiency $= 1 - \frac{Q_{out}}{Q_{in}}$

Show your working.

efficiency of boiler = ...

(ii) Give a value for an amount of energy that the boiler should take in to increase its efficiency.

(1)

....

(Total for Question 3 = 9 marks)

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4 Figure 3 is a diagram of a slinky spring being stretched.

Slotted masses are added to the end of the spring to increase the force stretching the spring.

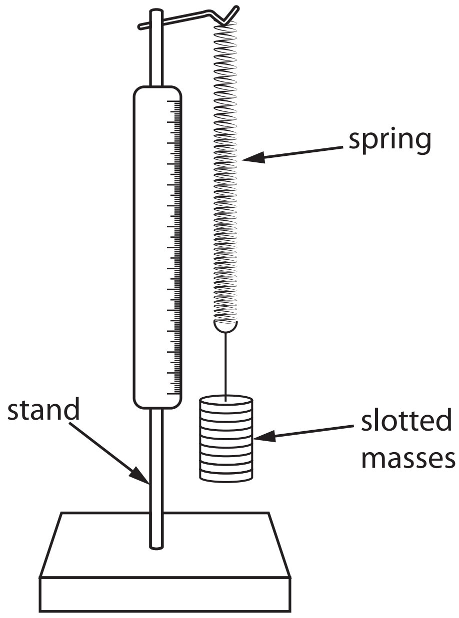

Figure 3

Figure 4 shows a graph of the data collected.

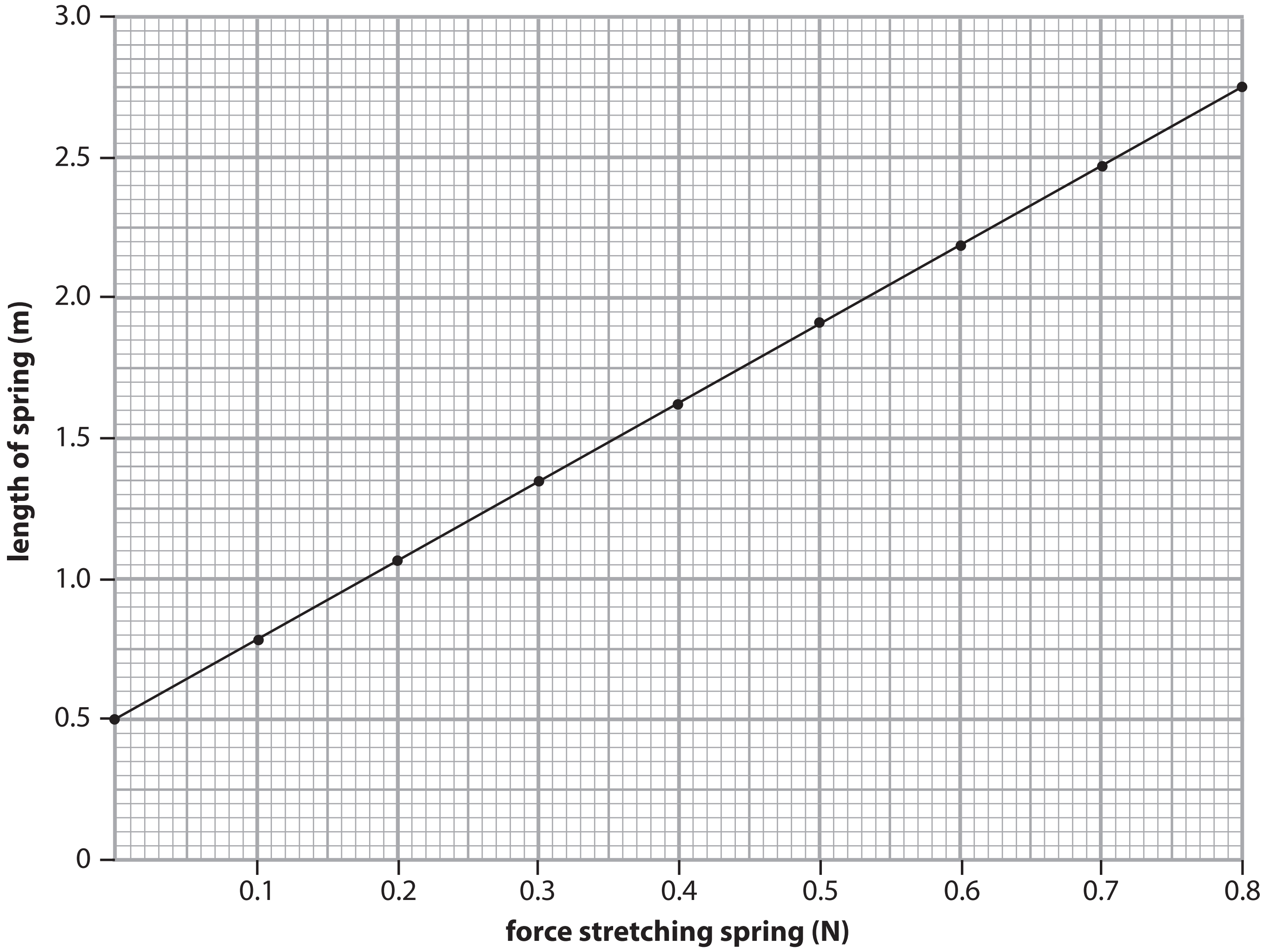

Figure 4

(a) (i) State how the graph shows that the slinky spring obeys Hooke's law.

(1)

....

....

(ii) Give the original length of the slinky spring.

(1)

.... m

(b) (i) Calculate the spring constant, k, of the slinky spring.

Show your working.

(4)

spring constant k = ... Nm^{-1}

(ii) A force of 0.5 N is hung from the slinky spring.

Calculate the work done by this force when stretching the spring.

Use the equation $\Delta E = \frac{1}{2} F\Delta x$

Show your working.

(3)

work done = ... J

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(c) Figure 5 shows the coils at the top and bottom of a slinky spring.

The coils at the top of the spring are further apart compared to the coils at the bottom of the spring.

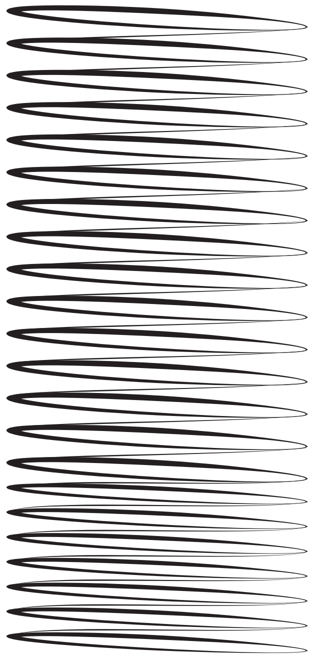

Figure 5

Explain why the coils are further apart at the top of the slinky spring than at the bottom.

(2)

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(Total for Question 4 = 11 marks)

5 (a) Viscosity is a property of a liquid.

Which **one** of these statements is correct for the viscosity of a liquid?

(1)

- ☒ **A** Viscosity is a measure of a liquid's resistance to movement.
- ☒ **B** Viscosity increases when the temperature of a liquid increases.
- ☒ **C** Viscosity is not affected by an increase in a liquid's pressure.
- ☒ **D** Viscosity is the measure of a liquid's flow pattern.

(b) Figure 6 shows two balloons suspended from a bar.

A student blows a constant flow of air between the two balloons.

The balloons move towards each other.

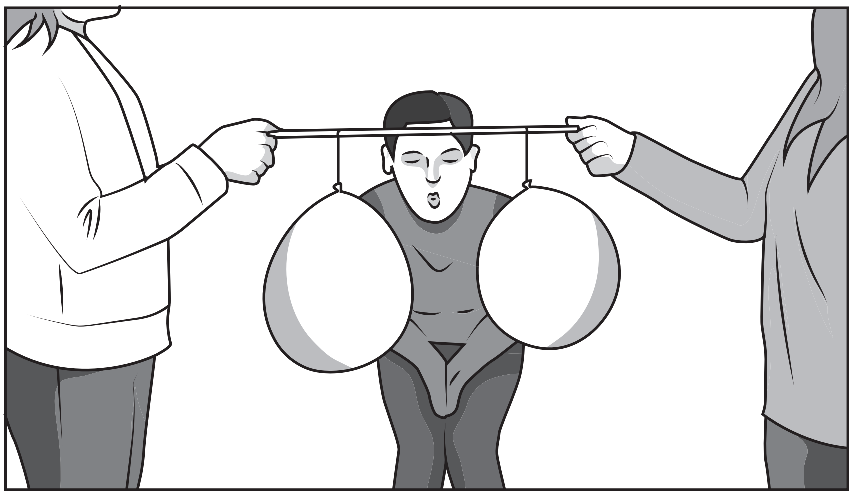

Figure 6

Explain, using Bernoulli's principle, why the two balloons move towards each other.

(2)

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(c) Figure 7 shows a glass bottle of tomato ketchup.

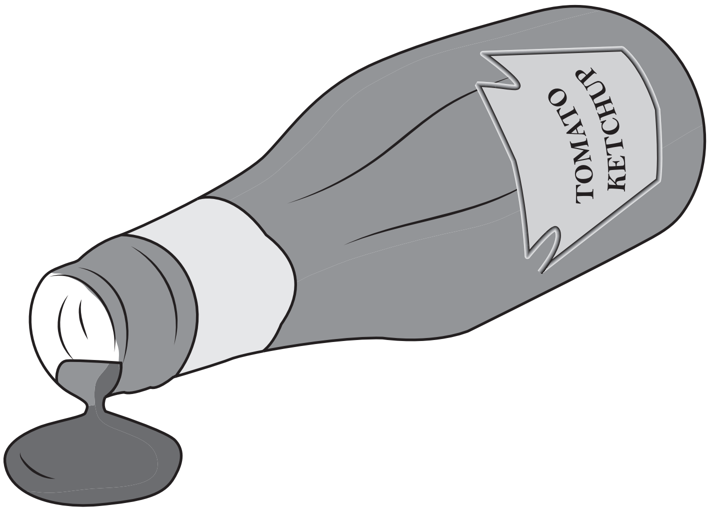

Figure 7

Tomato ketchup is a non-Newtonian fluid.

Tomato ketchup can sometimes get stuck in the glass bottle.

The glass bottle needs to be shaken to make the ketchup flow quickly.

Describe how shaking the glass bottle makes the ketchup flow quickly.

(3)

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(d) Figure 8 shows a water pipe. The water pipe has been dented in the middle.

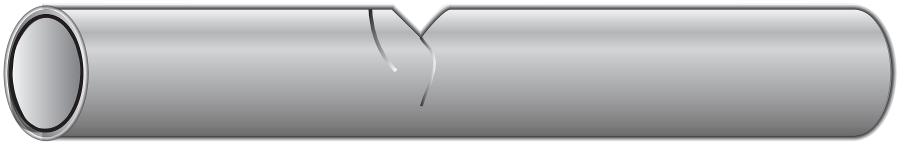

Figure 8

The water flow is streamlined before passing the dent.

The water flow is turbulent after passing the dent.

Compare the water flow and water viscosity before and after passing the dent in the water pipe.

(6)

You may draw diagrams to help your answer.

(Total for Question 5 = 12 marks)

TOTAL FOR SECTION C = 40 MARKS
TOTAL FOR EXAM = 120 MARKS

Formula Sheet

Mechanics

Work $W = F\Delta x$

Work done by a gas $W = p\Delta V$

Efficiency $\text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}}$

Efficiency for heat engines $\text{efficiency} = 1 - \dfrac{Q_{out}}{Q_{in}}$

Maximum theoretical efficiency $\text{efficiency} = 1 - \dfrac{T_c}{T_H}$

Thermodynamics

Ideal gas equation $\mathrm{pV = NkT}$

First law of thermodynamics $\mathrm{Q = \Delta U + W}$

Specific heat capacity $\mathrm{Q = mc\Delta T}$

Specific latent heat $\mathrm{Q = mL}$

Materials

Density $\rho = \dfrac{m}{V}$

Young modulus $E = \dfrac{\text{stress}}{\text{strain}}$

$$\text{stress} = \frac{\mathrm{F}}{\mathrm{A}}$$

$$\text{strain} = \frac{\Delta x}{L}$$

Hooke's law $\mathrm{F} = \mathrm{k}\Delta x$

Work done in stretching/ compressing a wire/spring $\Delta \mathrm{E} = \dfrac{1}{2}\mathrm{F}\Delta x$

$$\Delta \mathrm{E} = \frac{1}{2}k(\Delta x)^2$$

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