SPECIMEN PAPER

Birkdale School

Sixth Form Scholarship Examination

Physics

Time allowed: 1 hour 30 minutes

Instructions:

Attempt all four questions, time permitting.

Explain clearly your working and assumptions, using diagrams where appropriate.

Full marks for the parts of each question are indicated in square brackets.

Birkdale School

Sixth Form Scholarship Examination

Physics

Time allowed: 1½ hours

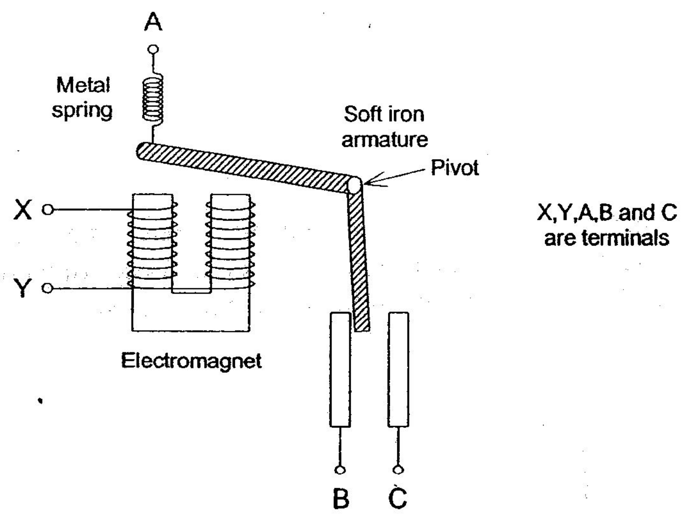
Attempt all four questions, time permitting.

Explain clearly your working and assumptions, using diagrams where appropriate.

Full marks for the parts of each question are indicated in square brackets.

1. The diagram shows a simple relay. X and Y are terminals connected to the coils of the electromagnet. A, B and C are terminals which can be connected to circuits of your choosing.

When there is no current flowing in the electromagnet, the terminals A and B are connected together; see diagram below

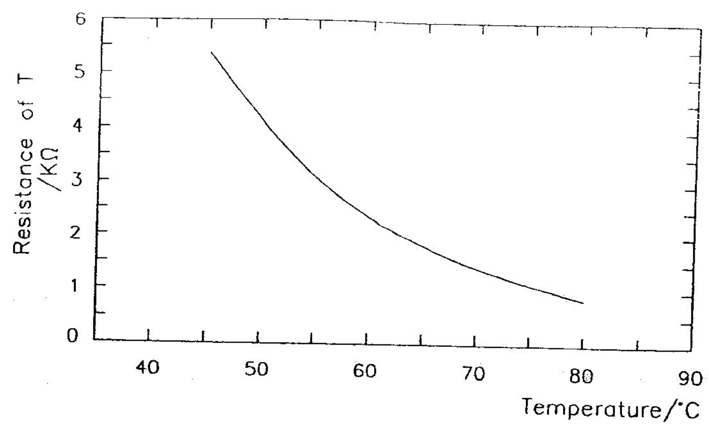


(a) Describe in detail what will happen when X and Y are connected to a battery? [2]

(b) The relay is used to switch on a mains alarm bell. The electromagnet coils are connected to a 9V battery, a switch S and resistor R. The alarm bell sounds when switch S is closed. Make a rough copy of the diagram above and add to your sketch the circuits you would connect to the terminals. [2]

(c) The relay coil has a resistance of 400 ohms. The relay will begin to operate when the coil current is 2 mA.
Calculate the resistance of R if the relay is just to operate when switch S is closed. [2]

(d) To make the circuit act as a fire alarm resistor R can be replaced with a sensor T whose resistance varies with temperature in the way indicated in the graph. At what temperature will the alarm bell initially ring? [2]



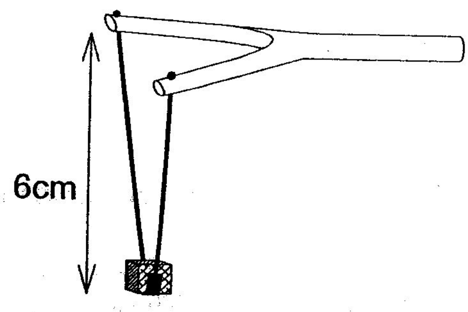
(e) **Describe a change you might make to the circuit in order to produce an alarm with an adjustable "turn on" temperature. Explain how it works.** [3]

(f) **Over what range can the temperature be set in your new circuit?** [1]

(g) **If you wished the alarm to sound when the temperature fell below a given value, what change might you make to the circuit?** [2]

Total [14]

2. **A student investigating how much stored energy is available in a stretched elastic band made a catapult, as shown in the diagram. The catapult fired small pieces of wood vertically upwards, and the height reached by the projectile was measured.**

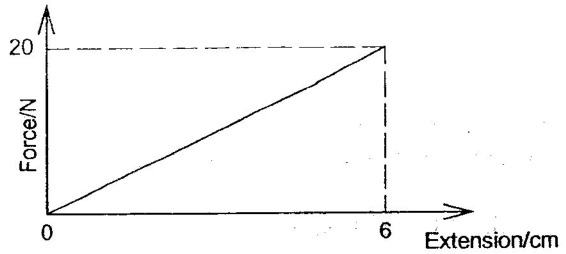


In one test, the elastic band was pulled downwards 6 cm. When released the wooden projectile of mass 20 grammes rose 1.25 m vertically above the catapult. (Air resistance was negligable)

(a) Calculate the gravitational potential energy gained by the projectile at its maximum height. (g=10 N/kg) [3]

(b) What was the kinetic energy of the projectile as it left the catapult? Give your reason. [2]

(c) The student wanted to compare this kinetic energy with the amount work that had been done on the elastic band in stretching it. A force of 20 N was needed to pull the band downwards by 6 cm. In fact the force applied to the band rose from zero, when the band's extension was zero, up to a maximum of 20 N when the band has been pulled down 6 cm. The variation in the force is shown in the graph below.



Calculate the <u>average</u> force applied. [2]

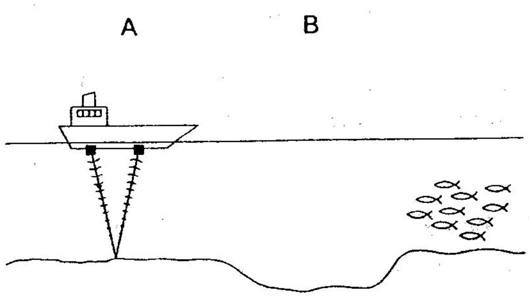
(d) Using this value of the average force, find the work that was done on the band in pulling it down 6 cm. [2]

(e) The work done on the band in stretching it was not the same as the kinetic energy of the projectile as it left the catapult.
Which was bigger? Suggest a reason for this. [3]

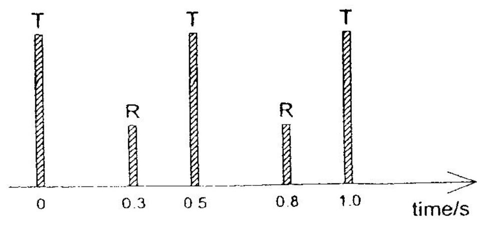
(f) Sketch a graph showing how the velocity of the projectile varied with time. Start the graph at the time the projectile left the catapult and finish at the time it had fallen back down to the catapult. [3]

Total [15]

3. Ultrasound is used in fishing boats for finding shoals of fish and checking the depth of the sea. A narrow beam of pulses is sent from the bottom of a boat, and the reflections are picked up by a detector.



The pulses are short bursts of 40 kHz sound. They are sent at 0.5 s intervals.
A screen on board the boat displays the transmitted (T) and reflected (R) signals. The diagram below shows what was seen on the screen when the boat was at position A.



The speed of ultrasound in water is 1500 m/s

(a) Calculate the depth of the sea at point A. [2]

(b) The boat moves to point B where the water is 300 m deep. At what times will the reflected signals be seen on the screen? [1]

(c) What difficulty is likely to arise when the depth of water is 375 m or more? [2]

(d) Why must the beam of ultrasound be narrow? [1]

(e) To ensure the beam is narrow the diameter of the ultrasound transmitter must not be too small. Explain why the size of the transmitter is important. [2]

(f) Calculate the wavelength of the ultrasound. Discuss whether a transmitter 40 mm in diameter would be too small. [5]

(g) The temperature of the sea is roughly constant down to a depth of 150 m. At greater depths the temperature falls rapidly, reducing the speed of sound. Give two reasons why this temperature change makes it difficult to obtain accurate measurements of water depth. [3]

Total [16]

4. Explain the following, with diagrams if appropriate, using terms you meet in physics.

(a) It is easier to cut cardboard with scissors if the cardboard is close to the pivot rather than at the ends of the blades. [3]

(b) If a frost is expected at night, a fruit grower might light slow burning smoky bonfires in the orchard at sunset. [3]

(c) The element of an electric fire gets hot but the wires carrying current to it do not. [3]

(d) You are using tracing paper to copy a diagram. Only if you press down hard on the tracing paper will the diagram be clearly visible. [3]

(e) A rubber balloon sticks to the ceiling when it has been rubbed on a woollen sweater. It falls to the ground after a short time. [3]

Total [15]