1. (a) (i) Count the number of turns *N* of the spring.

....

Remove the spring from the nails. Measure the diameter *D* of the coiled part of the unstretched spring. Draw a sketch to explain how you did this.

....

With the coils touching, measure the length *1* of the coiled part of the spring.

....

(6)

(ii) Calculate an approximate value for *L*, the length of wire forming the spring, given that $L = (N + 4)\pi D$.

....

....

L = ...

Calculate a value for the diameter *d l/N* of the wire from which the spring is made.

....

....

d = ...

Hence calculate the volume of wire $V = \pi d^2 l/4$.

....

....

V = ...

(3)

(iii) Use the balance provided to find the mass m of the spring.

....

Use your values of m and V to find a value for the density of the material of the spring.

....

....

(3)

(b) (i) Stretch the spring between the two nails. Use the meter and leads provided to find the resistance R of the **coiled** part of the spring. State any precautions that you took in making your measurement.

....

....

....

....

(3)

(ii) Use your values of N, D and d from part (a) to determine a value for the resistivity p of the material of the wire given that

$$p = \frac{Rd^2}{4ND}$$

....

....

....

....

(3)

(c) The energy stored in a stretched spring is $\frac{1}{2}Fx$ where x is the extension produced when a force F is applied to the spring, Use the apparatus provided to determine a value for the energy stored in the spring when it is stretched between the two nails. Describe with the aid of a diagram how you did this and show all your measurements and calculations in the space below.

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(6)

(Total 24 marks)

2. (a) (i) Pour hot water into the glass beaker up to the 200 ml (cm^3) mark. Record the temperature *0* of this water at regular intervals until the temperature falls below 70 °C. Your starting temperature should be above 80 °C.

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(4)

(ii) Plot a graph of temperature θ against time t on the grid opposite.

(4)

(iii) Use your graph to determine the rate at which the temperature is falling, $\Delta\theta/\Delta t$, when θ 75°C.

....

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....

....

Assuming that it takes 900 J of energy to raise the temperature of the beaker and water by 1 K (1 °C), estimate the power *P* of the heater that would be required to maintain the temperature of the water at a steady 75 °C.

(4)

(b) (i) A student performs a similar experiment using a datalogger to capture the data and a computer to determine $\Delta\theta/\Delta t$. She finds that the required power is 30 W.

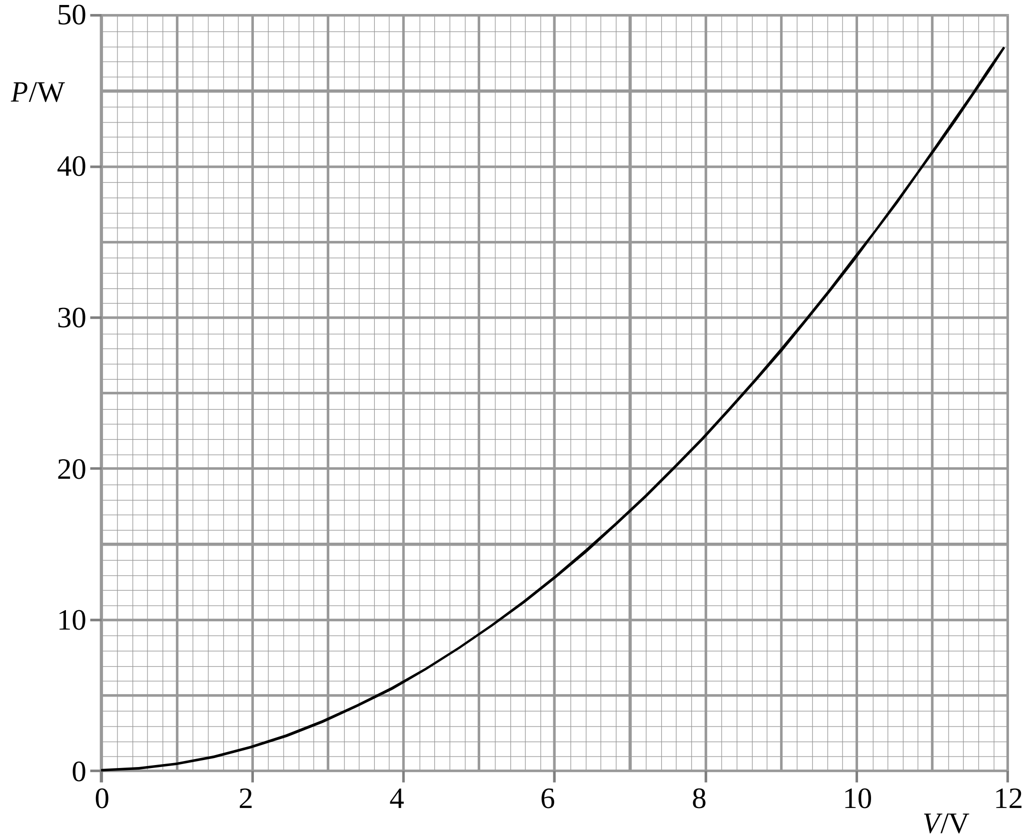
Draw a schematic (block) diagram to show the experimental arrangement and suggest a suitable sampling rate for the datalogger.

....

....

(4)

(ii) In a catalogue she finds a heater rated at 12 V, 48 W. Its power P varies with the applied potential difference V according to the following curve.



What potential difference would be required to provide a power of 30 W?

....

Describe, with the aid of a diagram, the circuit she could use to set the potential difference across the heater at the required value. You may assume that normal laboratory equipment is available.

....

....

(4)

(iii) After immersing the heater in 200 ml of water and setting the power to 30 W she wants to monitor the temperature of the water in this arrangement overnight and analyse the results next morning.

Explain how she could do this.

....

....

....

....

Suggest two reasons why she might find that the temperature had not remained at 75 °C.

....

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....

(4)
(Total 24 marks)

3. (a) (i) Taking care not to damage the card supplied, determine average values for the length *1*, the width *w* and the thickness *t*.

....

....

....

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....

....

Explain why it is necessary to take a number of values in order to determine accurate values for the above quantities.

....

....

(6)

(ii) Using the top pan balance, measure the mass of the card and hence find a value for the density of the material of the card.

....

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....

The value you have obtained for the average thickness of the card is not necessarily the best average value. Explain how you could obtain a better average value for the thickness. You may assume that additional apparatus is available.

....

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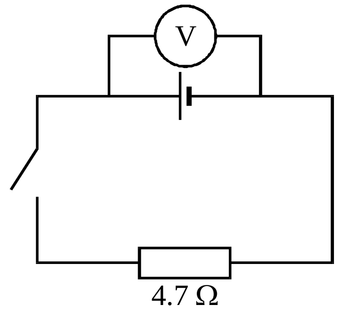
(4)

(b) (i) Set up the circuit as shown below. Before you close the switch, have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults, but if you are unable to set up the circuit the Supervisor will set it up for you. You will only lose 2 marks for this.



(2)

(ii) You may assume that the voltmeter is an ideal voltmeter which takes no current. Use your circuit to determine the e.m.f. *8* of the cell and the potential difference *V* across the 4.7 Ω 2 resistor.

ε = ...

V = ...

Leave the switch **open** after you have completed your readings.

(2)

(iii) Calculate the current *I* through the resistor.

....

....

Hence calculate the internal resistance *r* of the cell.

....

....

....

....

....

(3)

(c) (i) Place 50 cm^3 of water at room temperature in the polystyrene cup. Record the temperature θ_1 of the water.

θ_1 = ...

The Supervisor has placed 10 washers tied together with string in a beaker of boiling water. Using the string, remove the washers from the beaker and transfer them to the polystyrene cup. Record the highest steady temperature θ_2 reached by the water.

θ_2 = ...

Calculate the specific heat capacity c_s of mild steel given that

$$cs = \frac{m_W c_W (\theta_2 - \theta_1)}{m_s (\theta_3 - \theta_2)}$$

where $m_{w\,=}$ mass of water 0.050 kg,

c_w = specific heat capacity of water = 4200 J kg^{-1} K^{-1},

m_s = mass of 10 washers, which is given on the card,

θ_3 = initial temperature of washers = 100 °C.

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....

(5)

(ii) State two sources of error in this experiment.

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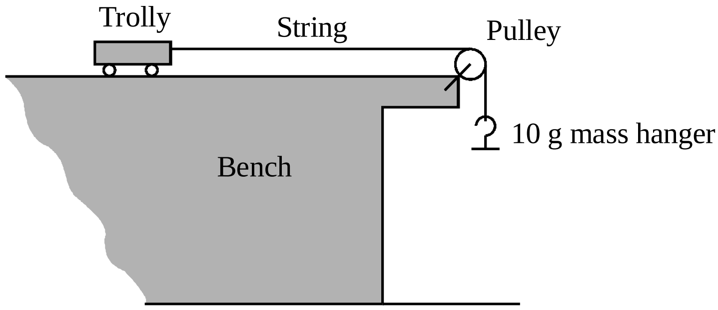
(2)
(Total 24 marks)

4. (a) The apparatus shown in the diagram below has been set up for you.



Add masses to the mass hanger until it is clear that the trolley accelerates across the table. Record the total mass m used to accelerate the trolley in the space below.

m =...

Determine the average time t for the trolley to travel a distance x 0.500 m from rest when accelerated by this mass.

....

....

Calculate the acceleration of the trolley given that

$$a = \frac{2x}{t^2}$$

....

....

....

....

Acceleration =..

(4)

(b) Explain with the aid of a diagram how you ensured that the trolley travelled a distance of 0.500 m in the measured time.

....

....

....

....

(3)

(c) Applying Newton's second law to this system gives

$$(M + m)a = mg - F$$

where M = the mass of the trolley and its load, which is given on the card,

F = the frictional force opposing the motion of the system, and

g = the gravitational field strength.

Use your results from part (a) to calculate a value for F.

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....

(3)

(d) Repeat the experiment with a larger value of m in order to calculate a second value for F

....

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....

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(4)

(e) Calculate the percentage difference between your two values of *F*. Comment on the extent to which the value of *F* may be regarded as constant if it is assumed that experimental errors are in the region of 10%.

....

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....

....

(2)

(f) The equation in part (c) may be investigated by plotting a graph of $(M + m)a$ against m.

(i) Explain carefully how you would carry out the experiment to plot this graph.

....

....

....

....

....

(3)

(ii) Sketch the graph you would expect to obtain if the force *F* were constant.

(3)

(iii) State the values you would expect to obtain for both the gradient and the intercept on the vertical axis.

....

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....

....

(2)

(Total 24 marks)

5. Instructions

For part (*a*):

1 Uniform wooden metre rule.

2 Five 2p coins

3 Five 1p coins.

4 Knife edge or prism to act as a fulcrum.

5 Set square.

For part (*b*):

6 12 V, 24 W lamp in suitable holder.

7 Approximately 15 V d.c. power supply, with switch.

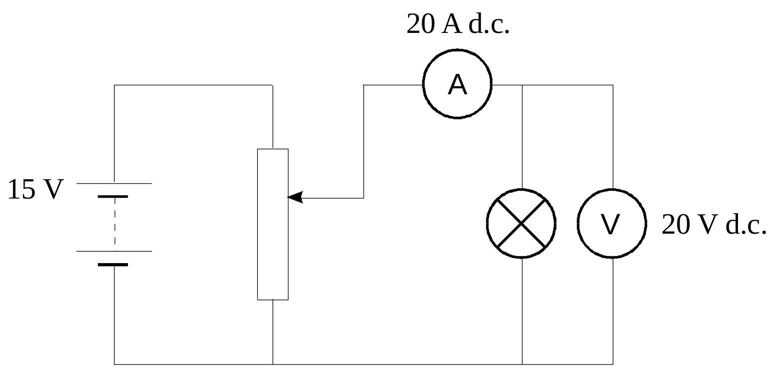
8 Ammeter, capable of reading up to 2 A d.c. to a precision of 0.1 A.

9 Voltmeter, capable of reading up to 15 V d.c. to a precision of 0.1 V.

10 Rheostat, e.g. 41 Ω, 2A.

11 Suitable connecting leads.

The *candidate* will be expected to use items 6 - 11 to set up the circuit below.



(a) (i) Determine a mean value for the diameters of a 1p coin and of a 2p coin. Describe how you did this.

....

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....

....

(4)

(ii) It is suggested that the mass of a 2p coin is twice that of a 1p coin. Use the principle of moments to investigate this hypothesis.

Draw a diagram of your experimental arrangement and show all your measurements and calculations below.

....

....

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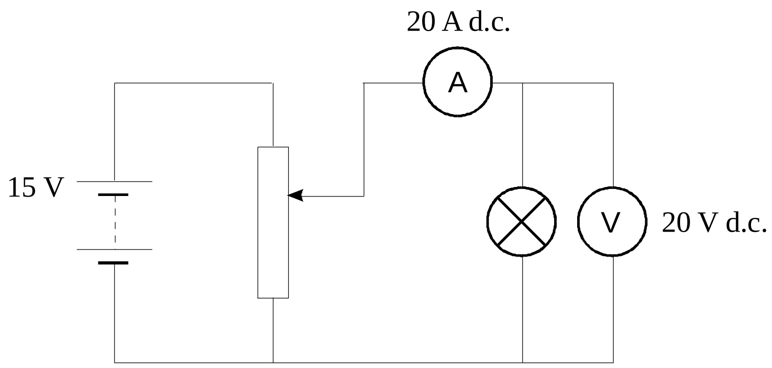
....

(6)

(b)



(i) Set up the above circuit to enable you to find the current through the lamp for a range of potential differences up to 12 V. Have your circuit checked by the Supervisor before switching on the power supply. If your circuit is incorrect you will be allowed a short time to correct it. If you are unable to do so, you may lose up to 3 marks.

(3)

(ii) Now carry out your experiment, recording your observations below.

SWITCH OFF THE POWER SUPPLY AS SOON AS YOU HAVE TAKEN YOUR READINGS.

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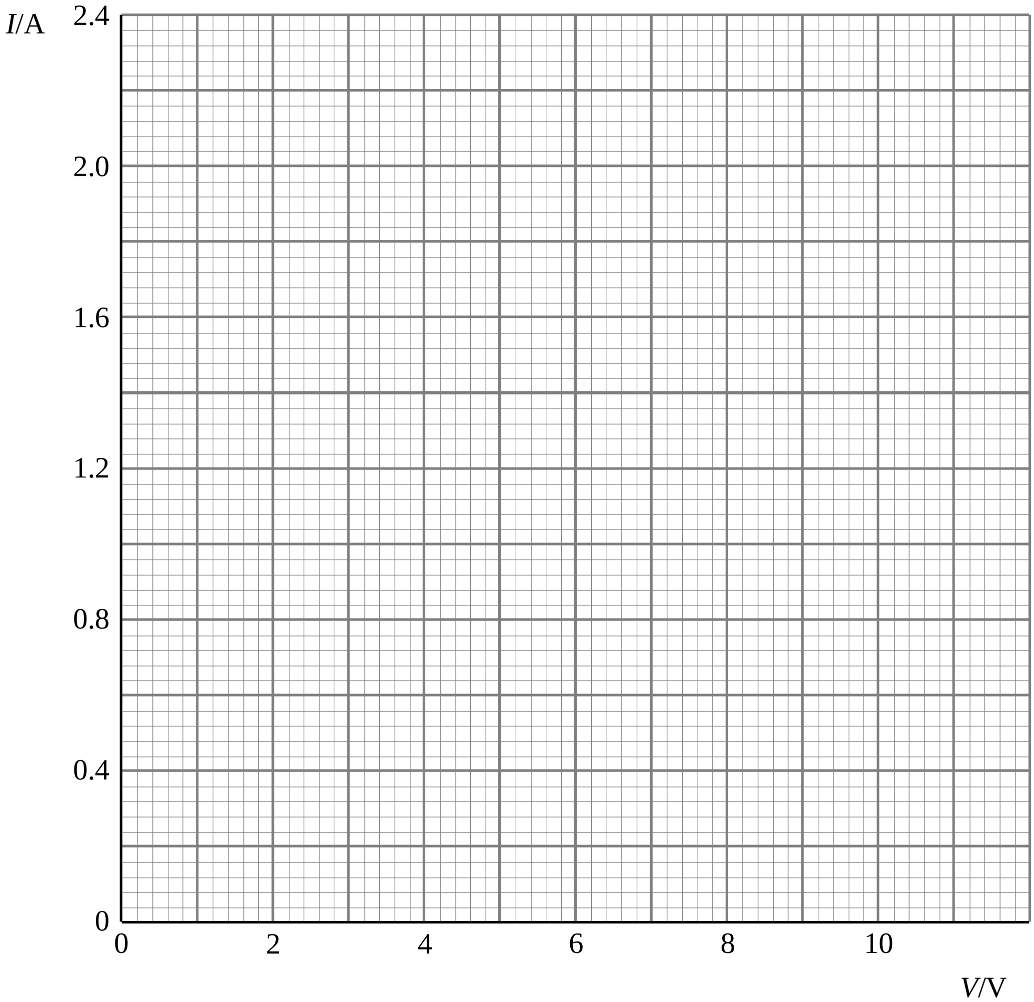
(5)

(iii) Plot a graph of the current I against the p.d. V on the grid below.

(2)



(iv) Use your graph to determine the resistance of the lamp when the p.d. across it is 4.5 V.

....

....

(2)

(v) The lamp is described as being a 12 V, 24 W lamp. Explain what this means and discuss the extent to which your experiment confirms this.

....

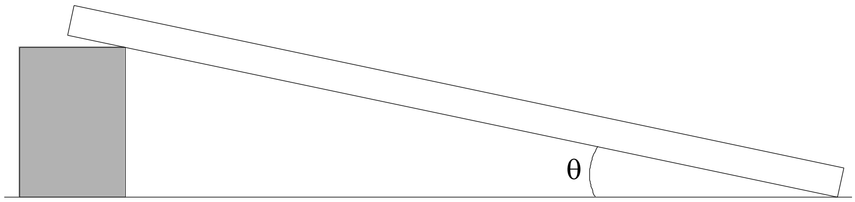
....

(2)
(Total 24 marks)

6. For part (*a*):

1 Runway of length approximately 1.2 m.

The runway, 1, should be of smooth board or m.d.f. (e.g. a length of shelving), approximately 20 cm wide and of sufficient thickness so that it does not bow. It should be supported securely at one end so that it makes an angle θ with the bench, such that tan θ = 0.025.



2 Ball bearing or marble of diameter between 1 cm – 2 cm..

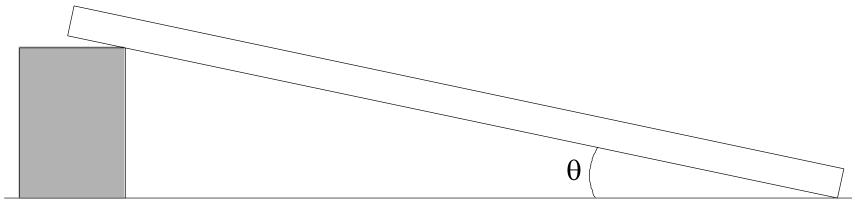
3 Stopwatch.

4 Two metre rules.

5 Small lump of Blu-tack.

6 Set square.

(a) A board has been set up ready for you to use. Do not adjust the angle θ it makes with the bench.



(i) Measure the angle θ that it makes with the bench, using a trigonometric method.

Describe how you did this. You may add to the diagram to illustrate your answer.

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Explain why using a protractor to determine θ would be a poor technique.

....

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(4)

(ii) Measure the time t for the ball to roll from rest a distance of 1.00 m down the slope.

Explain why taking repeat measurements is particularly important in this instance.

....

....

....

....

....

....

Calculate the acceleration a of the ball using

$$a = \frac{2x}{t^2} \quad \text{where } x = 1.00\text{m}$$

....

....

a =..

(5)

(iii) Calculate the percentage difference between this experimental value for a and the theoretical value $a = 0.71\, g \sin\theta$.

....

....

....

....

Percentage difference =............................

Account for the difference between your two values for *a*

....

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....

(4)

(b) (i) You are to plan how the experiment could be further developed to investigate the relationship $a = 0.71\, g \sin\theta$.

Describe the readings you would take and any calculations you would make.

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Sketch the graph you would plot.

Explain how you would use your graph to test the relationship.

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Explain how your graph would enable you to eliminate any systematic error due to the bench not being horizontal.

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(7)

(ii) It is suggested that the timing could be done better by a data logging device. Describe, with the aid of a diagram, how this could be done.

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....

(4)
(Total 24 marks)

7. (a) (i) Taking care not o damage the wire, determine values for the length l and the average diameter d.

....

....

....

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....

....

Explain why it is necessary to take several values of d.

....

....

(4)

(ii) Calculate the volume V of the wire given that

$$V = \frac{\pi d^2 l}{4}$$

....

....

Using the top pan balance, measure the mass of the wire and hence find a value for the density of the material of the wire.

....

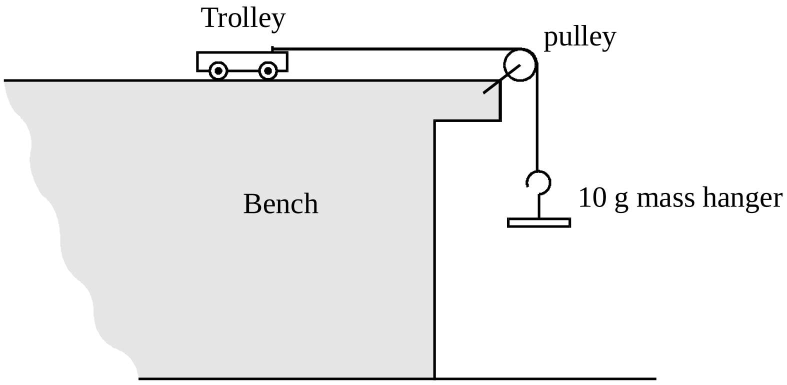
....

....

....

(3)

(b) (i) The apparatus shown in the diagram has been set up for you.



Add masses to the mass hanger until it is clear that the trolley accelerates across the table. Record the total mass m used to accelerate the trolley in the space below.

m = ...

Determine the average time t taken for the trolley to travel a distance x = 0.500 m from the rest when accelerated by this mass.

....

....

Calculate the acceleration a of the trolley given that

$$a = \frac{2x}{t^2}$$

....

....

....

....

(6)

(ii) Explain, with the aid of a diagram, how you ensured that the trolley travlled a distance of 0.0500 m in the measured time.

....

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....

....

(3)

(c) (i) Shake the beaker, which contains 48 coins (or discs), and throw the coins (or discs) into the tray. Remove all the coins which land with the head uppermost (or discs with the cross uppermost) and record the number N of coins (or discs) remaining in the tray. Place these coins (or discs) back int he beaker and repeat this process for three more throws. Tabulate N and the number x of throws in the space below.

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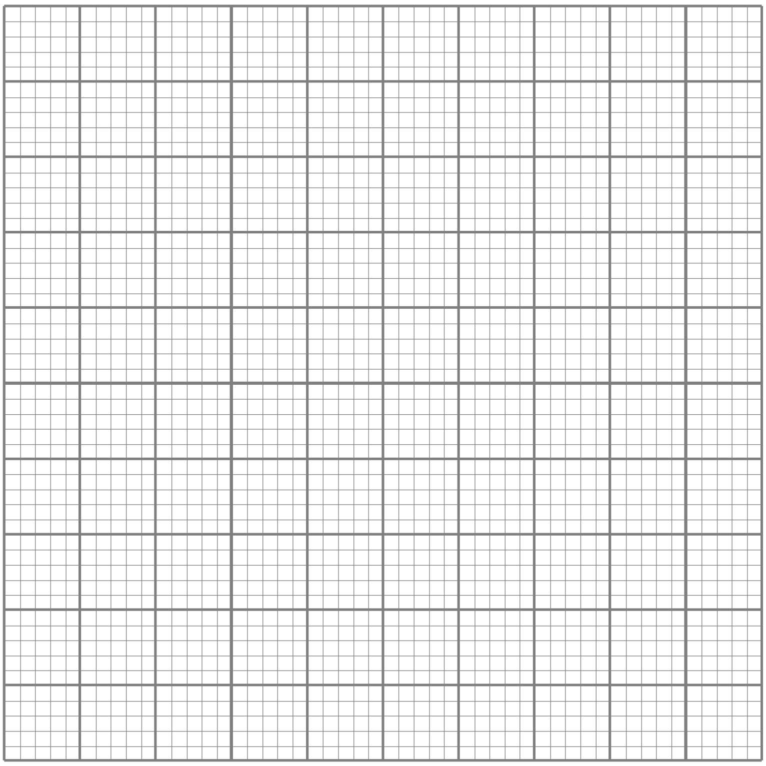
Using the grid below plot a graph of N against x. Draw the line of best fit through your points.



(5)

(ii) Discuss the extent to which your curve is a representation of a radioactive decay.

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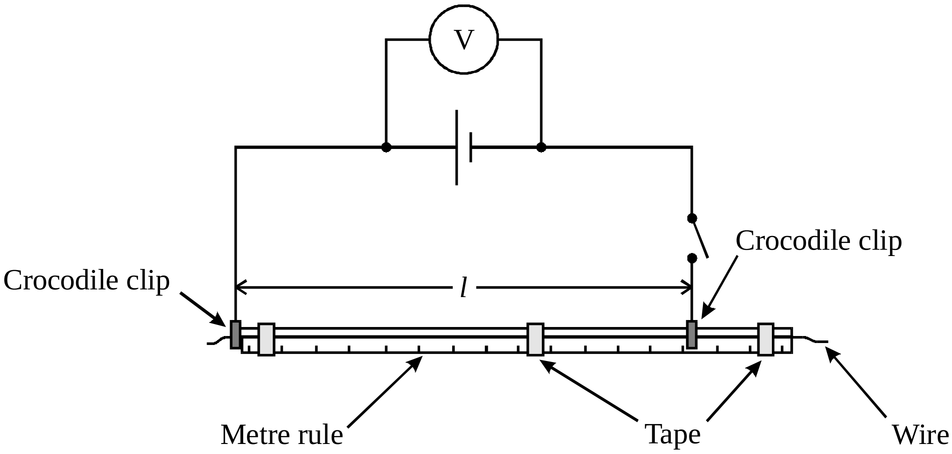
(3)
(Total 24 marks)

8. (a) Set up the circuit as shown in the diagram. The length of wire has already been attached to the metre rule. You should attach the crocodile clips to the wire so that the length *l* is 0.800 m. Before you close the switch have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults, but if you are unable to set up the circuit, the Supervisor will set it up for you. You will only lose 2 marks for this.



(2)

(b) You may assume that the voltmeter is an ideal voltmeter which takes no current. Use your circuit to determine the e.m.f. $\mathcal{E}$ of the cell and the potential difference *V* across the length *l* = 0.800 m.

$\mathcal{E}$ = ...

V = ...

If you are unable to do this ask the Supervisor for the card which will give you brief instructions. You will only lose 2 marks for this.

Leave the switch **open** when you have taken your readings.

(2)

(c) An equation which applies to this arrangement is

$$\frac{\mathcal{E}}{V} = 1 + \frac{k}{l}$$

Use you results from part (b) to determine a value for *k*.

....

....

....

....

(2)

(d) (i) Repeat part (b) using a length l of 0.400 m. Record your new values of ε and V, and calculate a second value for k.

....

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(3)

(ii) Explain, using your knowledge of electrical circuits, any changes which occur in the values of ε and V.

....

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....

(5)

(e) (i) Calculate the percentage difference between your two values of k. Comment on the extent to which the value of k may be regarded as constant if experimental errors amount to approximately 5%.

....

....

....

....

(ii) The constant k is given by

$$k = \frac{\pi d^2 r}{4p}$$

where r = internal resistance of the cell,
d = diameter of the wire (given on card),
ρ = resistivity of the material of the wire = 4.9×10^{-7} Ω m.

Using the average of your values for k calculate a value for the internal resistance of the cell.

....

....

....

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....

....

(4)

(f) Assuming that both $\mathcal{E}$ and k remain constant, the equation in part (c) may be investigated by plotting a graph of $1/V$ against $1/l$.

(i) Explain carefully how you would carry out the experiment to plot this graph.

....

....

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....

(ii) Sketch the graph you would expect to obtain.

(iii) Explain how both $\mathcal{E}$ and k could be obtained from the results.

....

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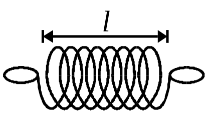
....

(6)
(Total 24 marks)

9. (a) (i) Count the number of turns N in the coiled part of the spring.

....

Measure as precisely as possible the length l of the coiled part of the spring when the coils are just touching.



....

....

Use your values of N and l to determine a value for the diameter d of the wire from which the spring is constructed.

....

....

(4)

(ii) Use the apparatus provided to find the extension x of the spring when different masses m are suspended vertically from the spring.

Plot a graph of x against m. Hence determine the mass M of the wooden block.

Show all your results below and use the grid below to plot your graph.

....

....

....

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....

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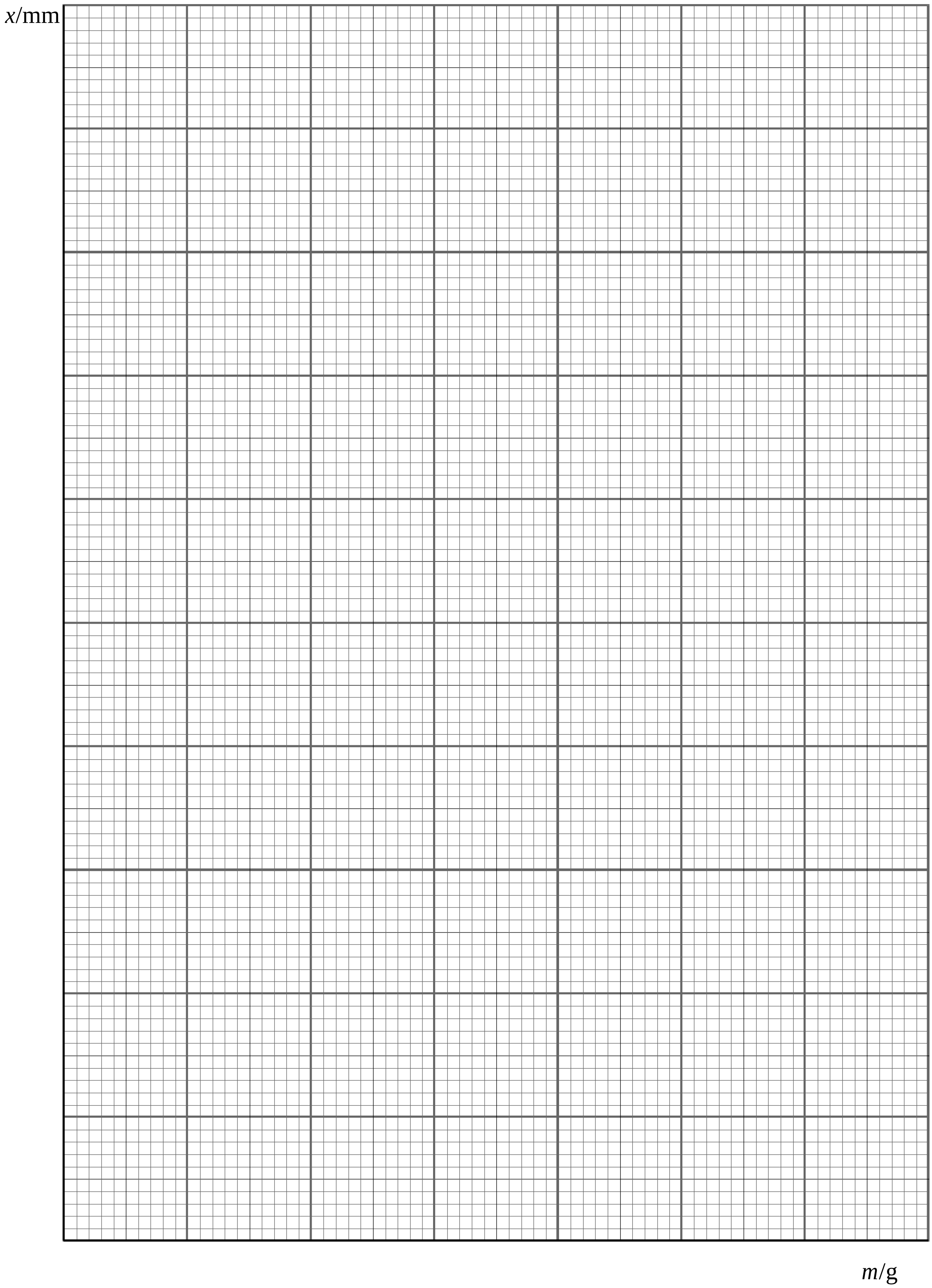
....



(8)

(b) (i) Use the electronic balance provided to find the mass of th*e candle and card. Use this mass and the data on the card to calculate the mass* m of the candle.

....

Pour 100 ml (cm^3) of water into the Pyrex beaker and place the candle under the beaker. **(Do not adjust the height of the beaker.)**

Use the candle to heat the water for 5.0 minutes and find the rise in temperature $\Delta\theta$ that this produces. Show your readings below and state any precautions that you took to ensure accuracy.

....

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....

Calculate a value for the power P of the candle assuming that

$$P = \frac{k\Delta\theta}{\Delta t}$$

where $k = 500 \text{ J K}^{-1}$ and Δt = time for which water was heated.

....

....

....

....

(6)

(ii) Use the balance to find the new mass of the candle and card. Hence find the mass Δm of wax that was burnt whilst heating the water.

....

....

Use this value of Δm and your value of m from part (i) to estimate for how long the candle would burn.

....

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The manufacturer claims that the candle "gives as much light as a small lamp and will last all night". To what extent does your experiment support this?

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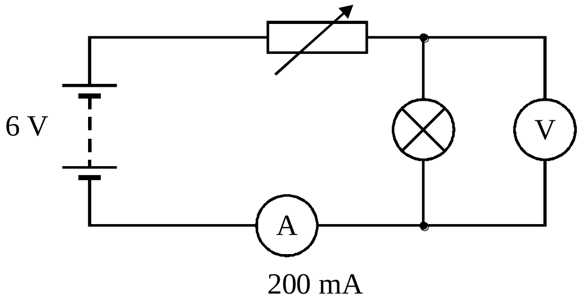
(6)
(Total 24 marks)

10. (a) (i) Set up circuit A as shown below.



Have your circuit checked by the Supervisor before switching on the power supply. You will be allowed a short time to correct any faults, but if you are unable to set up the circuit the Supervisor will set it up for you. You will only lose up to 3 marks for this.

Make measurements to determine the maximum and minimum values of current that this circuit can pass through the lamp.

....

(5)

(ii) Measure the p.d. *V* across the lamp when the current *I* is at its minimum value. Hence find the resistance *R* of the lamp.

....

....

....

Repeat the above to find the resistance of the lamp when the current is at its maximum value.

....

....

....

Discuss whether the lamp obeys Ohm's law.

....

....

....

(5)

(b) (i) It is suggested that $R = k\sqrt{I}$ where k is a constant.

Assuming that the total percentage uncertainty of the meters is 10%, discuss the extent to which your results confirm this relationship.

....

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....

(4)

(ii) Draw a circuit diagram to show how you would use the variable resistor as a potential divider to further investigate this relationship for values of *I* in the range 0–60 mA.

Describe how you would take the necessary readings.

....

....

....

....

Sketch the graph you would plot and state how you would use it to find a value for *k*.

....

....

....

....

(10)
(Total 24 marks)

11. (a) (i) Determine as precisely as possible a value for the diameter *d* of the golf ball.

....

....

Calculate the volume *V* of the golf ball using $V = \pi d^3/6$.

....

Use the balance provided to find the mass *m* of the golf ball and hence a value for the average density *p* of the material from which it is made.

....

(5)

(ii) Golf balls are sold in packs of three. If the packet is rectangular in shape, and the three golf balls just fit inside, how much "wasted space" is there in the packet?

....

....

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....

If the packet is made from rigid plastic, describe how you could check your answer experimentally.

....

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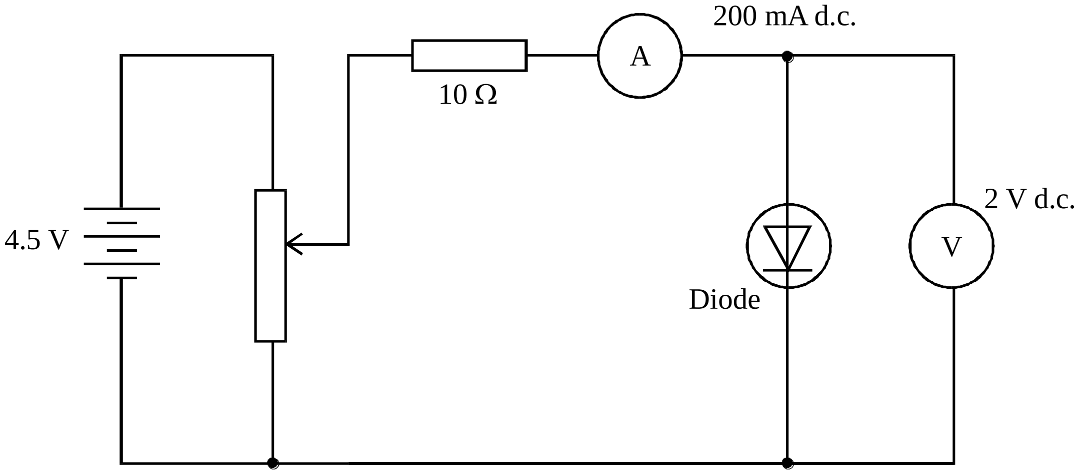
(5)

(b) (i) Set up the circuit below to find the current *I* in the diode for a range of potential differences *V* across it up to a maximum current of 100 mA.



Have your circuit checked by the Supervisor before connecting the power supply. You will be allowed a short time to correct any faults, but if you are unable to set up the circuit the Supervisor will set it up for you. You will only lose up to 3 marks for this.

(3)

(ii) Now carry out your experiment, recording your observations below.

DISCONNECT THE POWER SUPPLY AS SOON AS YOU HAVE TAKEN YOUR READINGS.

....

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....

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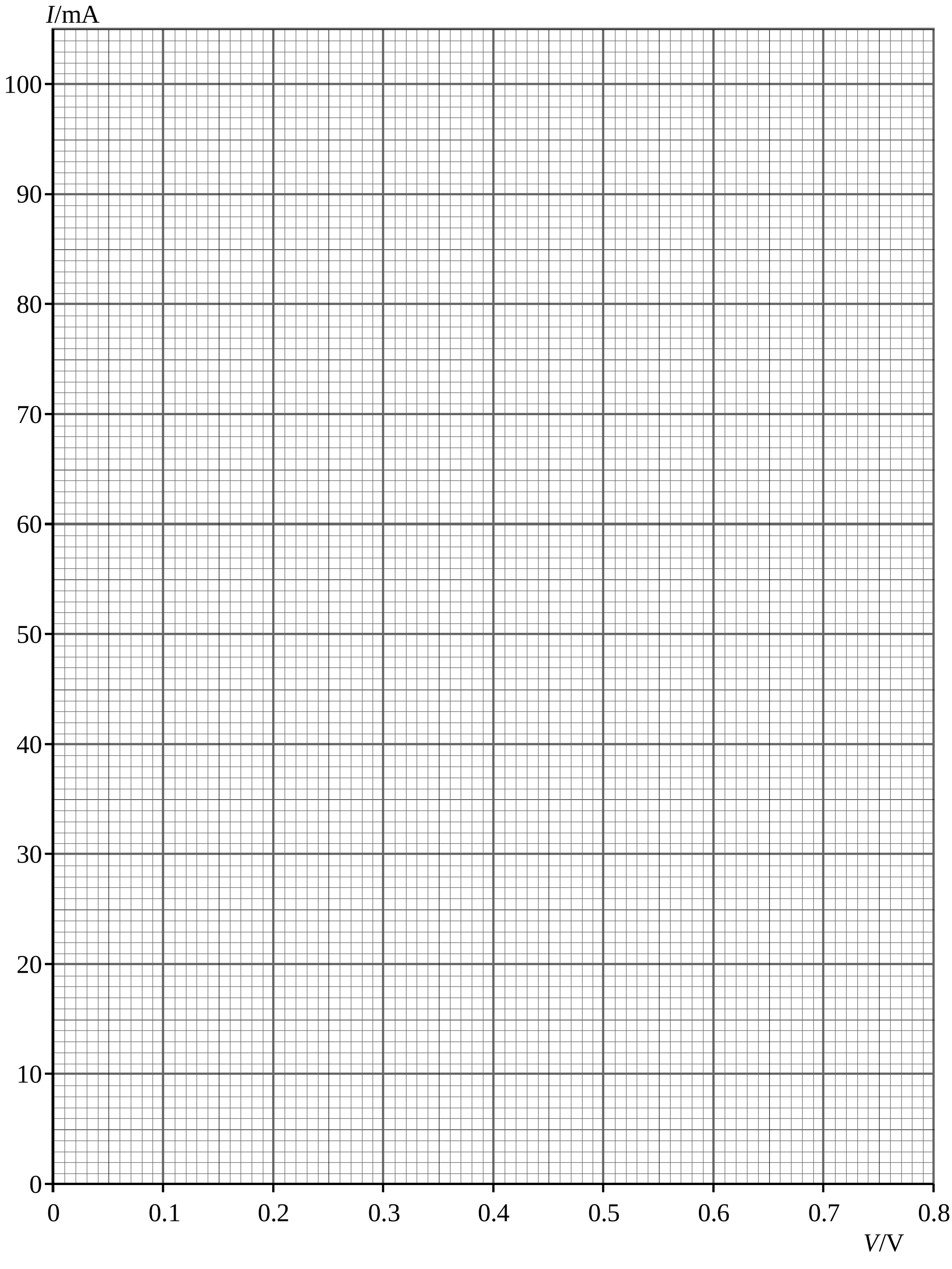
....

....

(5)

(iii) Plot a graph of the current I against the p.d. V on the grid below.



(2)

(iv) Use your graph to determine the resistance of the diode when the p.d. across it is 0.70 V.

....

....

....

What is the current through the diode when its resistance is 50 Ω?

....

....

....

....

(4)
(Total 24 marks)

12. (a) The depression x at the centre of a rule supported symmetrically between two knife edges is given by the expression

$$x = \frac{Mgl^3}{4Ebd^3}$$

where M = mass suspended at centre of rule
g = gravitational field strength
l = distance between knife edges
b = width of rule
d = thickness of rule
E = a property of the material of the rule, called its Young modulus.

(i) Make accurate measurements of b and d for the **metre rule**.

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(4)

(ii) Set up the apparatus to enable you to determine a value for x when l = 0.800 m and M = 1.00 kg.

Draw a diagram of your arrangement in the space below, showing clearly your values of l and x. Explain, with the aid of your diagram, how you measured x as accurately as possible.

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(5)

(iii) Record your value of x. Estimate the percentage uncertainty in your value.

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(2)

(iv) Use your measurements to calculate a value for E. The unit for E is kg m^{-1} s^{-2}.

....

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(3)

(b) You are to plan how the experiment could be further developed to investigate the relationship between x and l given by the expression in (a), using only the apparatus provided.

(i) Describe the readings that you would take.

....

....

(2)

(ii) Sketch the graph you would plot.

Explain how you would use your graph to test the relationship.

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(4)

(iii) Explain how you would use your graph to calculate a value for E.

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Explain why using your graph in this way gives a more accurate value for E than your value in part (a).

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(4)
(Total 24 marks)

13. (a) (i) You have been provided with a sheet of foil. Measure its length *I* and width *w*. Explain with the aid of a diagram how you obtained accurate values for *I* and *w*.

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(3)

(ii) Determine the thickness *t* of the sheet by folding it so that a total thickness of 16*t* is recorded. Estimate the percentage uncertainty in your value of *t*.

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Explain one advantage and one disadvantage of measuring *t* in this way.

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(6)

(iii) Calculate the volume *V* of the sheet.

....

....

Measure the mass of the sheet using the balance provided and hence determine the density of the material from which the sheet is made.

....

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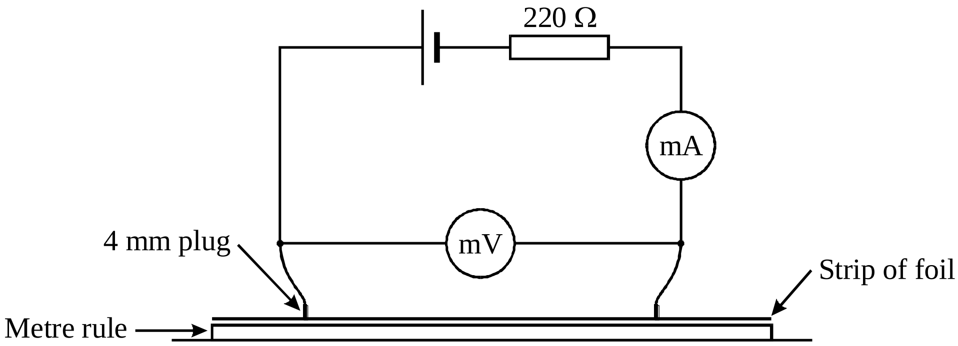
....

(3)

(b) (i) Set up the circuit as shown in the diagram below to enable you to measure the resistance of an 80.0 cm strip of foil. Before pressing the 4 mm plugs on to the foil, have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults. If you are unable to set up the circuit the Supervisor will set it up for you. You will only lose two marks for this.



(2)

(ii) Taking care not to damage the foil, press the ends of the 4 mm plugs firmly against the strip of foil so that you can measure the voltage V across a length l = 80.0 cm. Also measure the current I in this length. Record your measurements in the space below.

....

....

Hence calculate a value for the resistance R of the 80 cm length of foil.

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(4)

(iii) Explain whether your value for R is likely to be greater than, equal to or less than the actual resistance of this length of foil.

....

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....

....

(2)

(iv) Calculate a value for the cross-sectional area A through which the current is passing. You may assume that the width of the strip is 5.0 mm and that its thickness is the same as that determined in part (a).

....

....

Use your results to determine a value for the resistivity ρ of the material from which the foil is made. This is given by

$$\rho = \frac{RA}{l}$$

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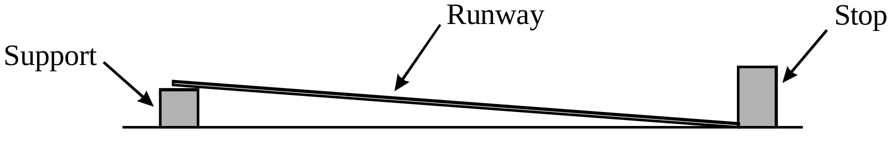
(4)

(Total 24 marks)

14. (a) Set up the apparatus as shown in the diagram below with support A placed under one end of the runway and the stop secured at the other end.



Determine the mean time t for the ball to travel a distance s of 1.00 m from rest down the runway.

....

....

Hence calculate the speed υ of the ball after moving 1.00 m, which is given by

$$\upsilon = \frac{2s}{t}$$

....

....

(3)

(b) Determine the vertical height h through which the ball falls as it travels this distance of 1.00 m down the runway. Draw a diagram to show how this height was determined.

h =..

Using the mass of the ball, which is given on the card, calculate the potential energy E_p lost by the ball as it falls through the height h.

....

....

Using your results from part (a) calculate the linear kinetic energy E_K gained by the ball as it moves down the runway.

....

....

Because the ball has both linear and rotational kinetic energy in this experiment, it is expected that $E_p = kE_K$, where k is a constant. Use your energy values to calculate a value for k.

....

....

(6)

(c) Repeat parts (a) and (b) of the experiment using support B in order to obtain a second value for *k*.

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(5)

(d) Determine the percentage difference between your two values of *k*. If the total experimental uncertainty in the energies is of the order of 20%, comment on the validity of assuming that *k* is constant.

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....

(2)

(e) You are to plan an experiment to further investigate the equation $E_p = kE_K$. Your plan should include

(i) a description of how E_p can be changed,

(ii) a description of the experiment to be performed,

(iii) a sketch graph showing the expected results,

(iv) an indication of how the constant *k* may be found from the graph.

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(8)
(Total 24 marks)

15. (a) (i) You are provided with 10 glass spheres. Determine an accurate value for the average diameter d of the spheres. Explain with the aid of a diagram how you tried to ensure that d was determined as accurately as possible.

....

....

....

....

(5)

(ii) Estimate the percentage uncertainty in your value for *d.*

....

....

(2)

(iii) Calculate the average volume V of a sphere given that

$$V = \frac{\pi d^3}{6}$$

....

....

....

....

(1)

(iv) Use the balance provided to determine the average mass of a sphere. Record all your measurements. Use your data to calculate a value for the density of the glass from which the spheres are made.

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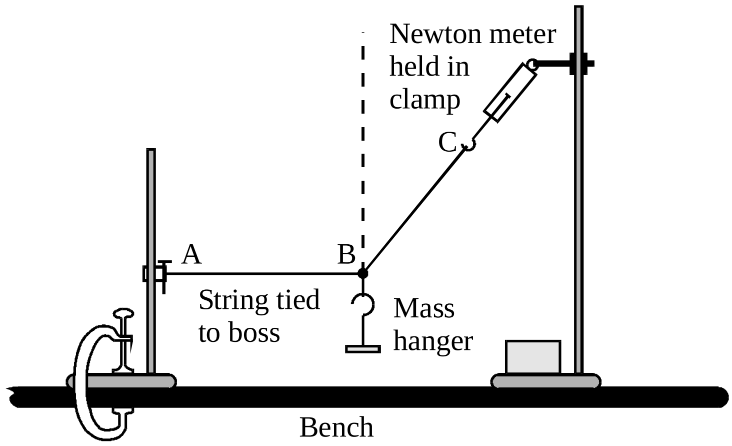
(4)

(b) (i) The apparatus shown in the diagram below has already been set up for you.



Place 300 g on the mass hanger to give a total mass *M* of 400 g. Adjust the height of the clamp holding the newton meter until the section of string AB is horizontal. Explain carefully how you ensured that the string was horizontal, adding to the above diagram if you wish. Record the reading *R* on the newton meter.

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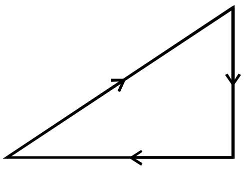
(4)

(ii) Draw a free-body diagram to show the forces acting at the point B, carefully labelling the forces.

(3)

(iii) The diagram below shows the equilibrium of the three forces acting at point B.



Add your data to the diagram and calculate the tension in the horizontal section of the string.

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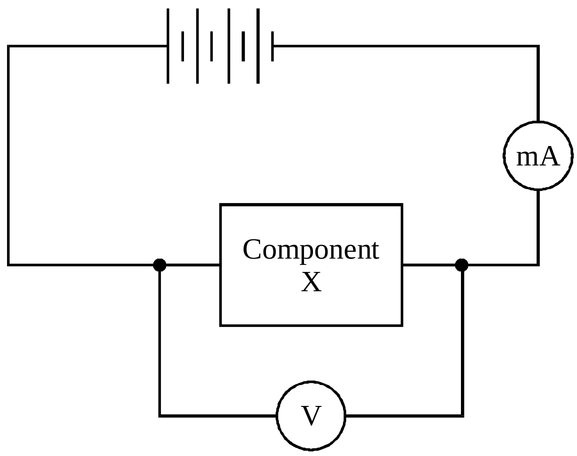
(5)

(Total 24 marks)

16. (a) (i) Set up the circuit as shown in the diagram below. Before you connect the power supply have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults, but if you are unable to set up the circuit the Supervisor will set it up for you. You will only lose 2 marks for this.



Connect the 6 V supply to the circuit with the positive terminal of the power supply connected to terminal T of component X. Record the current I_1 in and the voltage V_1 across X.

....

....

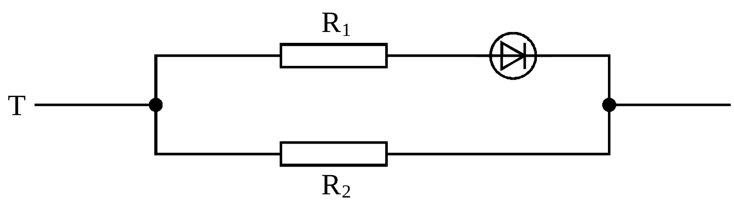
(ii) Reverse component X and measure the new values of the current I_2 in and the voltage V_2 across X.

....

....

(6)

(b) Component X contains the elements shown in the diagram below.



Use your results from part (a) to deduce the resistance of the resistor R_2.

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....

(4)

(c) The voltage drop across a conducting diode may be assumed to be 0.70V. For the situation when both arms of component X are conducting, calculate

(i) the current in the resistor R_2,

....

....

....

(ii) the current in the series arrangement of the diode and the resistor RI,

....

....

....

(iii) the resistance of resistor R_1.

....

....

(6)

(d) (i) Draw a circuit diagram to show how you would use a potential divider to further investigate the current-potential difference relationship for component X.

Describe how you would take the necessary readings.

....

....

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....

(3)

(ii) Sketch a graph of the results you would expect. You may assume that a diode does not start to conduct until the voltage drop across it exceeds 0.70 V.

Explain how the resistance of the resistor R_2 may be found from the graph.

....

....

....

....

(5)
(Total 24 marks)

17. (a) The runway has been set up at the angle given on the card. Do not adjust.

(i) Determine the time t taken for the trolley to travel a distance *s* = 0.800 in from rest along the runway.

....

....

(2)

(ii) Explain, with the aid of a diagram, any special precautions which you took to ensure that *t* was as accurate as possible.

....

....

....

....

(3)

(iii) Estimate the percentage uncertainty in your value of *t*.

....

....

....

....

(2)

(iv) Calculate the acceleration a of the trolley given that

$$a = \frac{2s}{t^2}$$

....

....

....

....

(1)

(v) Calculate the frictional force F opposing the motion of the trolley which is given by

$$F = mg\sin\theta - ma$$

where m = the mass of the trolley, which is given on the card,
θ = the angle of inclination of the slope, which is given on the card,
g = the gravitational field strength.

....

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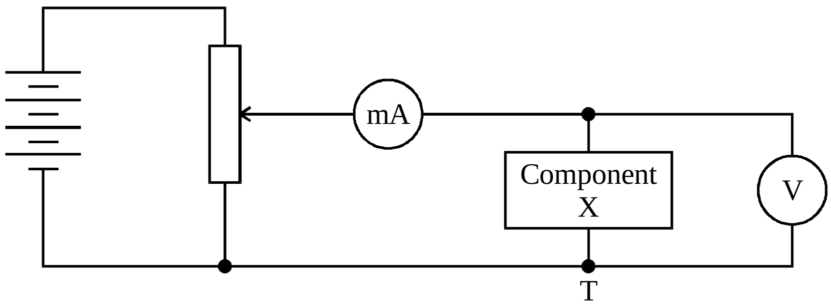
....

....

(2)

(b) (i) Set up the circuit as shown in the diagram below with the negative of the power supply connected to terminal T of component X. Before you connect the positive of the power supply, have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults, but if you are unable to set up the circuit the Supervisor will set it up for you. You will lose no more than 3 marks for this.



(3)

(ii) Complete the circuit and set the current I_1, to 20 mA. Record the voltage V_1 across component X.

....

....

(1)

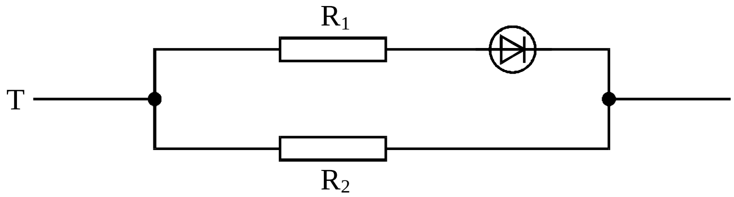
(iii) Reverse component X and set the current I_2 to 40 mA. Record the voltage V_2 across component X.

....

....

(1)

(iv) Component X contains the elements shown in the diagram below.



Use your results from part (ii) to deduce the resistance of the resistor R_2.

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(3)

(v) The voltage drop across a conducting diode may be assumed to be 0.70 V. For the situation in part (iii) when both arms of component X are conducting, calculate

the current in the resistor R_2,

....

....

....

the current in the series arrangement of the diode and the resistor R_1,

....

....

....

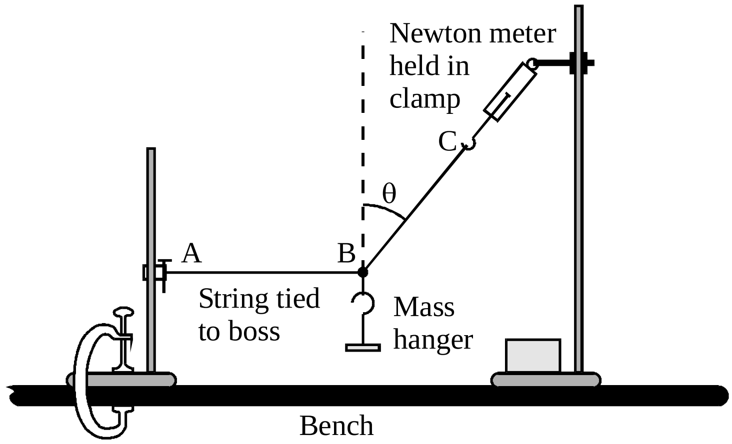
the resistance of the resistor R_1.

....

....

(6)
(Total 24 marks)

18. (a) The apparatus shown below has already been set up for you.



Place 300 g on the mass hanger to give a total mass *M* of 400 g. Adjust the height of the clamp holding the newton meter until the section of string AB is horizontal. Explain carefully how you ensured that the string was horizontal, adding to the above diagram if you wish. Record the reading *R* on the newton meter.

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....

(4)

(b) Record the length 1 of the section BC of the string. The position of C is marked on the string.

l = ...

Record the vertical height h between the points B and C on the string.

h = ...

Explain carefully how you measured *h*. You may add to the diagram opposite if you wish.

....

....

....

....

Use your values of l and h to calculate cos θ where θ is the angle shown on the diagram.

....

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....

(6)

(c) If the section AB of the string is horizontal, theory suggests that

$$\cos\theta = \frac{W}{R}$$

where W = weight of the suspended mass,
and R = the reading on the newton meter.

Calculate W/R.

....

....

The uncertainty in the newton meter reading may be taken to be 0.2 N. Calculate the percentage uncertainty this would give in your value for R. Discuss whether this alone could account for any difference between your value for W/R and your value of cos 0 as calculated in (b).

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(6)

(d) You are to plan an experiment to verify the equation shown in part (c).

(i) Describe the experiment you would perform.

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....

(ii) Sketch the graph you would expect to obtain and explain how you would use it to verify the equation.

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....

(8)
(Total 24 marks)

19. (a) (i) You are to determine the volume V of the Plasticene by a displacement method. Shape the Plasticene so that it will fit into the measuring cylinder. (You are advised to wear a disposable glove.) After you have shaped it, measure its mass m.

m = ...

Now place sufficient water in the measuring cylinder to ensure that the Plasticene is fully immersed. This may take several trials. Draw diagrams showing the sequence of your experimental arrangements and record all your measurements in the space below.

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....

State any special precautions which you took when determining *V*.

....

....

....

....

Use your values of *m* and *V* to calculate a value for the density of Plasticene.

....

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....

....

(7)

(ii) Calculate the percentage uncertainty in your value for *V*.

....

....

....

Manufacturers quote the density of Plasticene as 1800 kg m^{-3} (1.8 g cm^{-3}) ± 10%.

Calculate the percentage difference between your value for the density and that quoted by the manufacturers.

....

....

Assuming that the percentage uncertainty in the mass is negligible, comment on the extent to which the Plasticene you used meets the manufacturers' specification.

....

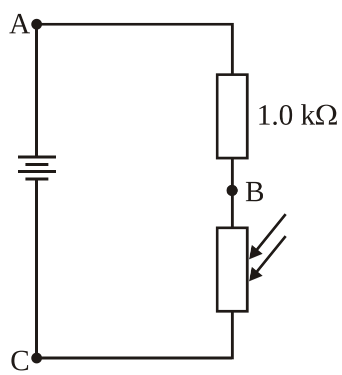
....

....

....

(4)

(b) (i) Set up the circuit as shown in the diagram below. Before connecting to the power supply, have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults. If you are unable to set up the circuit the Supervisor will set it up for you. You will lose only two marks for this.



(2)

(ii) Connect the voltmeter between points A and C to measure the terminal potential difference V_{AC} of the power supply.

V_{AC} = ...

Now connect the voltmeter between points B and C to measure the potential difference V_{BC} across the light dependent resistor (LDR).

V_{BC} = ...

Hence calculate the potential difference V_{AB} across the 1.0 kΩ resistor.

V_{AB} = ...

Calculate the current I in the circuit and the resistance R of the LDR.

....

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(5)

(iii) Keeping the voltmeter between points B and C, cover the LDR with the disc. Using your knowledge of potential dividers, explain what happens to V_{BC} when the LDR is covered by the disc.

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Calculate a value for the resistance R of the LDR when it is covered by the disc.

....

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....

(6)
(Total 24 marks)

20. (a) The apparatus has been set up for you. Do not adjust it in any way. Determine the mean time t for the trolley to descend a distance s of 0.80 m from rest down the runway.

....

....

Hence calculate the speed υ of the trolley after moving 0.80 m, which is given by

$$\upsilon = \frac{2s}{t}$$

....

....

(3)

(b) Explain with the aid of a diagram how you ensured that the trolley travelled a distance of exactly 0.80 m.

....

....

....

....

(3)

(c) Determine the vertical height h through which the trolley moves as it travels a distance of 0.80 m down the runway. Draw a diagram to show how this height was determined.

h = ...

Using the mass of the trolley, which is given on the card, calculate the potential energy E_p lost by the trolley as it moves through the height h.

....

....

Using your results from part (a), determine the kinetic energy E_k gained by the trolley as it moves down the runway.

....

....

In this experiment it is expected that $E_p = E_k + k$ where k is a constant. Calculate a value for k.

....

....

(6)

(d) You are to plan an experiment to further investigate the equation in part (c). Your plan should include

(i) a description of how E_p can be changed,

(ii) a description of the experiment to be performed,

(iii) a sketch graph, showing the expected results.

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How would you find k from the graph?

....

(8)

(e) The speed of the trolley at the end of the 0.80 m run has been found by doubling the average speed of the trolley as it moves down the runway. Describe how this final speed could be measured directly using a datalogging system.

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(4)
(Total 24 marks)

21. (a) (i) Check that the rod part of the stand labelled S is of uniform cross-section by taking suitable measurements. Your method and all your measurements should be shown below.

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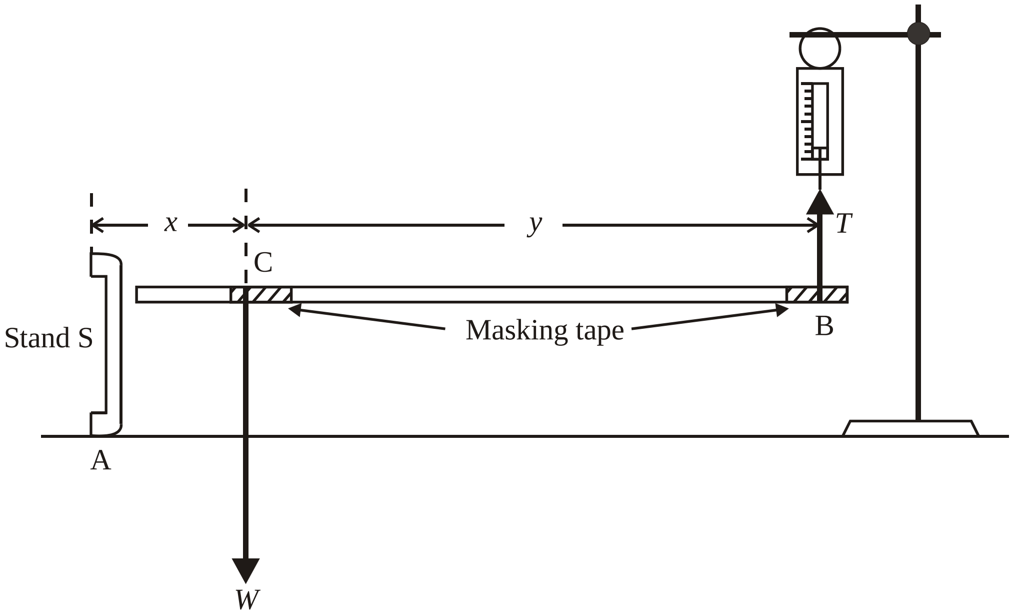
(4)

(ii) Balance the stand on the knife edge so that the rod is horizontal. Mark on the piece of tape the position C of the balance point. Now set up the arrangement shown below.



Support the rod with the newton-meter at a point B on the tape near the end. Mark this point.

Adjust the height of the newton-meter so that the rod is horizontal. Explain how you ensured that the rod was horizontal.

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(1)

(iii) The principle of moments shows that

$$W = \frac{T(x + y)}{x}$$

where W is the weight of the stand and T is the newton-meter reading.

Measure and record the distances x and y, and record the value of T.

x ....

y ....

T ....

Use these data to calculate a value for the weight W of the stand.

....

....

(4)

(iv) Estimate the percentage uncertainty in your value for y. Discuss the difficulty of estimating the percentage uncertainty for x.

....

....

....

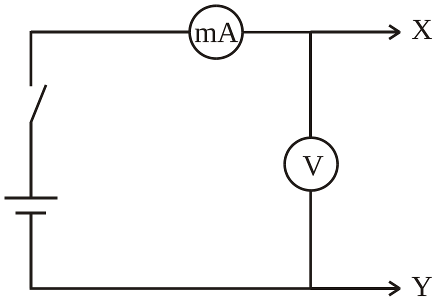
....

....

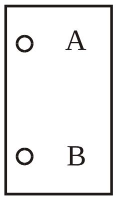
....

(3)

(b) (i) Set up the test circuit as shown in the diagram. Leads X and Y are labelled. Before you switch on the power supply, have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults, but if you are unable to set up the circuit, the Supervisor will set it up for you. You will only lose two marks for this.



Test circuit



Unknown circuit

(2)

(ii) Connect X to A and Y to B to measure the current in and the voltage across the unknown circuit.

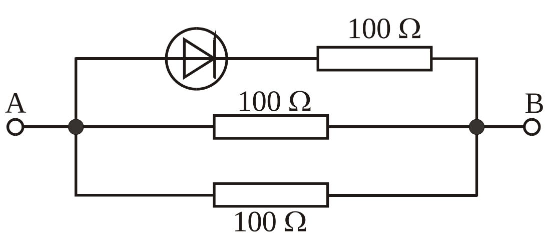
Repeat this with X connected to B and Y connected to A.

Summarise your results in the table below. Complete the table by inserting appropriate units and determining the resistance in each case.

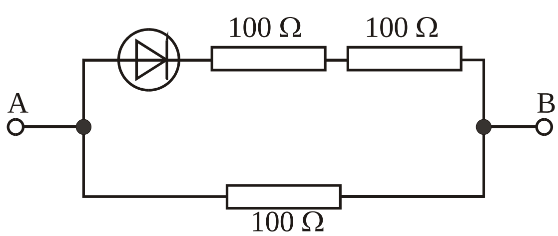
X connected to	Y connected to	Current/	Voltage/	Resistance/
A	B			
B	A			

(4)

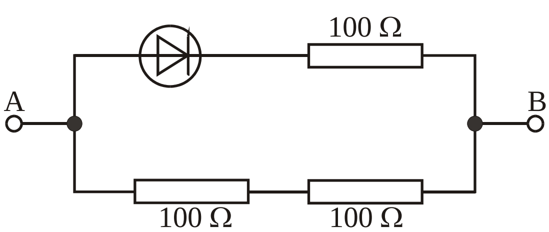
(iii) A technician makes up the following 3 circuits for an examination such as this.



J



K



L

Explain carefully which of the circuits is the one you tested.

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(3)

(iv) Deduce the resistance of the diode when it is conducting.

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(3)
(Total 24 marks)

22. (a) Record the temperature θ_0 of the water in the beaker labelled 'Water at room temperature'.

....

Pour 20 cm^3 (20 ml) of this water into the measuring cylinder.

The beaker which is labelled 'For hot water' has a horizontal line drawn on it at the 100 cm^3 mark. Fill the beaker to the horizontal line with boiling water from the kettle. You are now to measure the fall in temperature $\Delta\theta$ of this hot water when 20 cm^3 of the water at room temperature is added. Record the temperature θ_i of the hot water just before the 20 cm^3 is added and the temperature θ_f just after the water is added. Show all your measurements and calculations in the space below. State any special precautions which you took to ensure an accurate value for $\Delta\theta$.

....

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....

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....

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....

....

(5)

(b) For the mixing of a fixed volume of hot water and a fixed volume of water at room temperature it is suggested that

$$\Delta\theta = k(\theta_f - \theta_0)$$

where k is a constant.

Using your results from part (a) determine a value for k.

....

....

....

....

(3)

(c) You are now to repeat the experiment using a lower value of θ_i, keeping the volume of hot water as 100 cm^3 and the volume of added water at 20 cm^3. Describe carefully how you can do this without refilling the beaker with hot water. Record your results and determine a second value for k.

....

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....

....
(5)

(d) Determine the percentage difference between your two values of k. Comment on the extent to which your results confirm the suggested relationship, assuming that the total experimental error is of the order of 10%.

....

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....

....
(3)

(e) Describe how you would continue the experiment in order to investigate more fully the suggested relationship. Your account should include

(i) a description of what you would do,

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(ii) a sketch of the graph that would be plotted, showing the expected result,

(iii) an indication of how the value of k could be determined from the graph.

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(8)
(Total 24 marks)

23. (a) (i) Check that the metre rule labelled R is of uniform width and thickness by taking suitable measurements. Your method and all your measurements should be shown below.

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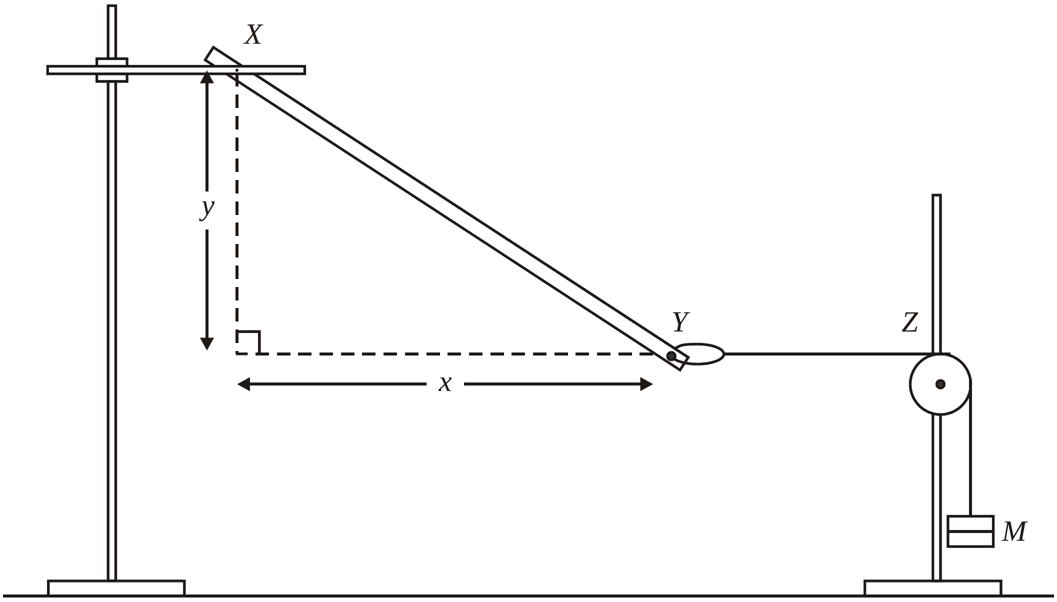
(4)

(ii) The arrangement shown below has been set up ready for you to use.



Adjust the height of the pulley and/or the position of the stands so that the string YZ is horizontal. Measure the distances x and y.

x ....

y ....

The principle of moments gives the equation

$$W = 2Mg\frac{y}{x}$$

where W is the weight of the suspended rule and Mg is the weight of the slotted masses. You may assume $M = 0.200$ kg. Use this equation to find the weight W.

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(5)

(iii) Explain how you measured *x* and *y*, adding to the diagram above if you wish.

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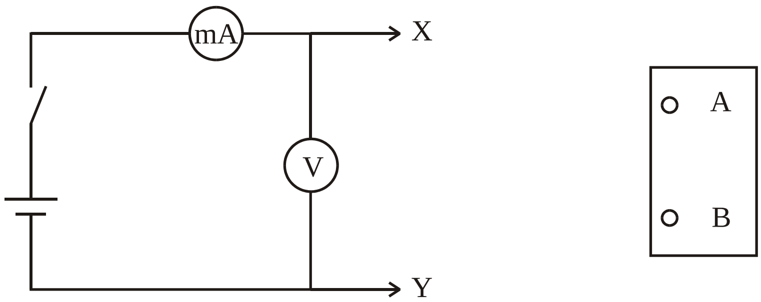
(3)

(b) (i) Set up the test circuit as shown in the diagram. Leads X and Y are labelled. Before you switch on the power supply, have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults, but if you are unable to set up the circuit, the Supervisor will set it up for you. You will only lose two marks for this.



Test circuit   Unknown circuit

(2)

(ii) Connect X to A and Y to B to measure the current in and the voltage across the unknown circuit.

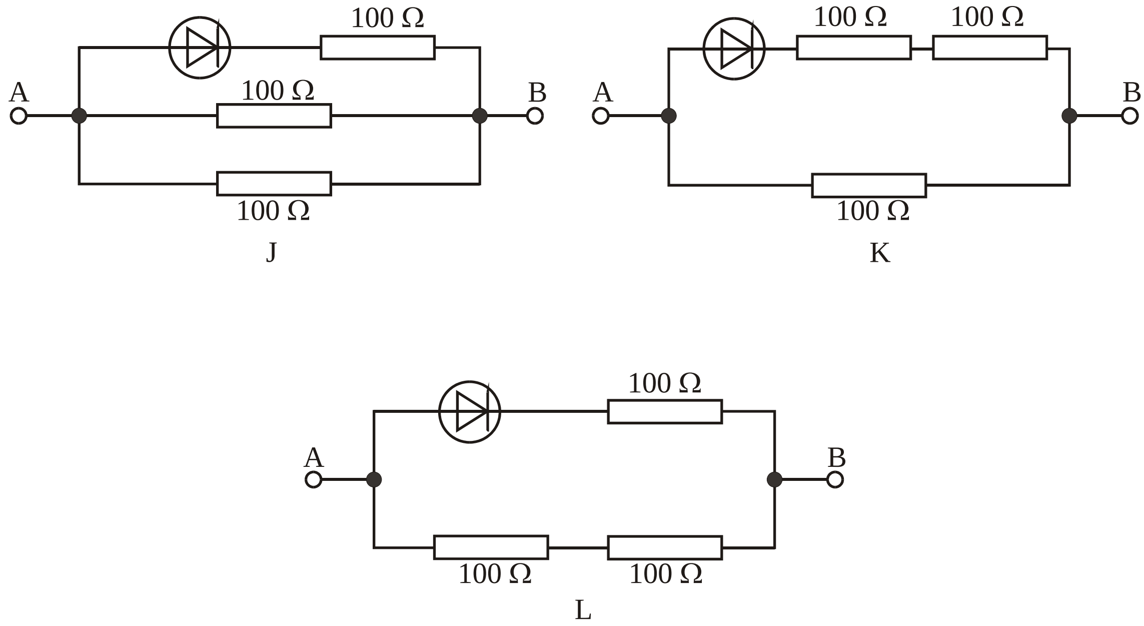
Repeat this with X connected to B and Y connected to A.

Summarise your results in the table below. Complete the table by inserting appropriate units and determining the resistance in each case.

X connected to	Y connected to	Current/	Voltage/	Resistance/
A	B			
B	A			

(4)

(iii) A technician makes up the following 3 circuits for an examination such as this.



Explain carefully which of the circuits is the one you tested.

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(3)

(iv) Deduce the resistance of the diode when it is conducting.

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(3)
(Total 24 marks)

24. (a) Pour a known volume V of water at room temperature into the beaker containing the coil of resistance wire so that the coil of wire and the bulb of the thermometer are just covered. Describe how you did this. Record the volume V and the temperature θ_0 of the water in the space below.

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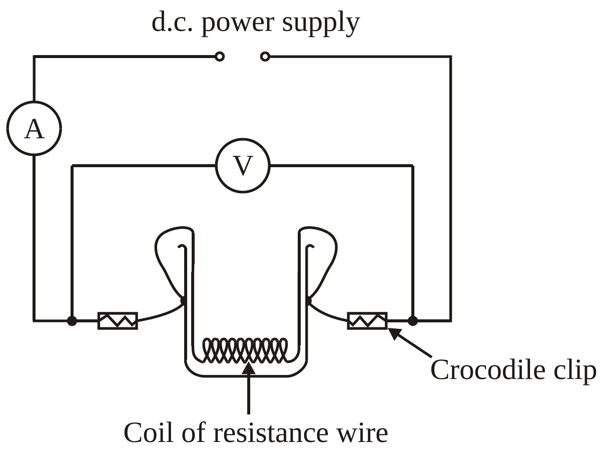
(2)

(b) The circuit has been set up ready for you to use.



Switch on the power supply and start the stopwatch. Record the temperature θ of the water as a function of the time t for a period of 5 minutes. Tabulate your readings in the space below. Also record the current I in the circuit and the potential difference V across the coil of wire.

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(5)

(c) Using the grid below plot a graph of θ against t.

(3)

(d) Draw the best straight line through your points. Determine the rate of rise of temperature $\Delta\theta/\Delta t$ from the gradient.

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If all the power P supplied by the coil of wire is used to heat the water then

$$P = m_w c_w \frac{\Delta\theta}{\Delta t}$$

where m_w = mass of water in the beaker and c_w = specific heat capacity of the water.

Using your results from part (b), calculate P and hence determine c_w assuming that a volume of 1.0 cm^3 (1.0 ml) of water has a mass of 1.0 g.

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(6)

(e) State whether your value of c_w is likely to be too high or too low. Give a reason for your answer.

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State two ways in which the experiment could be made more accurate.

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(4)

(f) Draw a circuit diagram to show how a thermistor may be used in a potential divider circuit to produce a temperature sensor.

Draw a block diagram to show how a datalogger may be used to collect data from this temperature sensor.

(4)
(Total 24 marks)

25. (a) (i) Measure the mass m_b of the 250 cm^3 (250 ml) beaker. You have access to a top pan balance. Pour the salt into the beaker and measure the total mass m_t of the beaker and salt. Hence determine the mass m of salt.

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Fill the measuring cylinder with water to within a few cm^3 of 100 cm^3. Record this volume.

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Pour this water into the beaker. Repeat the process. Record your second volume.

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State the total volume transferred to the beaker.

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Stir the water thoroughly so that a salt solution is formed. Assuming that 1.00 cm^3 (1.00 ml) of water has a mass of 1.00 g and that there is no change in liquid volume as the salt dissolves, calculate the theoretical value for the density of the salt solution.

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(3)

(ii) Use the apparatus provided and the top pan balance to find the density of the salt solution experimentally. To gain full credit you must show all your working.

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(5)

(iii) Estimate the percentage uncertainty in your value for the volume of the solution.

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Assuming that the uncertainty in your mass values is negligible, discuss whether your two values for the theoretical and experimental density of the solution indicate that there is a change in the volume when the salt is dissolved in water. Your answer should be based on a quantitative argument.

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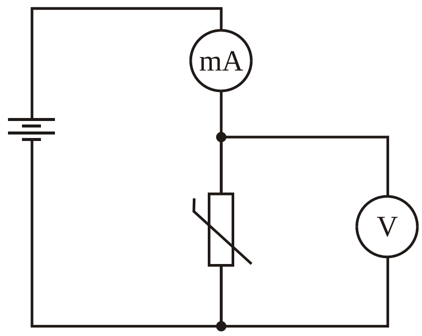
(4)

(b) (i) Set up the circuit as shown in the diagram below. Before connecting to the power supply have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults. If you are unable to set up the circuit the Supervisor will set it up for you. You will only lose two marks for this.



(2)

(ii) Using the space below, record the potential difference V across the thermistor and the current I in the thermistor.

V = ...

I = ...

Hence calculate a value for the resistance R of the thermistor.

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(3)

(iii) You are to observe how the current changes with time as you warm the thermistor and then sketch a graph of this.

Hold the thermistor between your thumb and forefinger and observe what happens to the current in the thermistor. Continue holding the thermistor until the current reaches a steady value. Record the final steady values for the current I_f in the thermistor and the potential difference V_f across it.

V_f ....

I_f ....

Hence calculate a second value R_f for the resistance of the thermistor.

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In the space below **sketch** a graph of the current in the thermistor against the time for which the thermistor is held.

(7)
(Total 24 marks)

26. (a) (i) The apparatus has been set up ready for you to use and should not be moved.

Approximately half fill the beaker with the hot water provided. Quickly pour this water into the plastic cup up to the marked line, which is calibrated to give 100 cm^3 of water in the cup.

Observe the temperature of the water in the cup and start the stopwatch when the temperature reaches 80.0 °C. Record the temperature θ at regular intervals of time t for five minutes.

Tabulate your readings in the space below.

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(5)

(ii) Plot a graph of θ against t on the grid below.

(4)

(iii) Determine the gradient $\Delta\theta/\Delta t$ of your graph when θ = 70.0 °C.

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Hence calculate the rate at which the water is losing energy when θ = 70.0°C, given that the density of water is 1.0 g cm^{-3} (1000 kg m^{-3}) and its specific heat capacity is 4.2 J g^{-1} K^{-1} (4200 J kg^{-1} K^{-1}).

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(4)

(b) (i) It is suggested that an insulated cup could be made by using two cups with an air gap between them.

Draw a labelled diagram to show how you could do this with the apparatus provided.

(2)

(ii) Outline the steps you would take in repeating the experiment with the double cup in order to test its insulating properties compared with the single cup.

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(3)

(iii) In the space below, sketch the results you would expect to get. You should sketch the curves for the single cup and the double cup on the same set of axes. Label your curves.

(3)

(iv) It is suggested that the double cup should insulate at least twice as well as the single cup. Explain how you would test this from the curves that you have sketched in part (iii).

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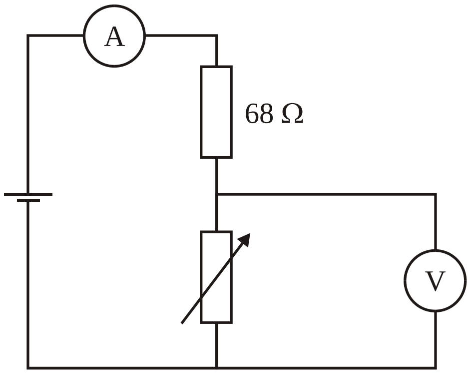
(3)
(Total 24 marks)

27. (a) (i) Using the voltmeter provided measure the potential difference between the terminals of the cell. Because the voltmeter has a very high resistance, you may assume that this reading is the e.m.f. E of the cell.

E = ...

(1)

(ii) Set up the circuit shown in the diagram below. Before you connect your circuit to the cell, have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults. If you are unable to set up the circuit, the Supervisor will set it up for you. You will lose only two marks for this.



(2)

(iii) Connect the cell to your circuit and adjust the variable resistor until the potential difference V_1 across the variable resistor is approximately $\frac{1}{2}E$. Record V_1 and the corresponding current I_1.

V_1 = ...

I_1 = ...

Hence calculate the resistance R_1 of the variable resistor at this setting.

....

....

....

....

(3)

(iv) Using your knowledge of potential dividers, what is the expected value of R_1 when V_1 is $\frac{1}{2}E$?

....

....

Calculate the percentage difference between your value of R_1 and the expected value.

....

....

....

(2)

(v) Repeat the experiment with the potential difference V_2 across the variable resistor set to approximately $\frac{1}{4}E$. Record V_2 and the corresponding current I_2.

V_2 = ...

I_2 = ...

Calculate the resistance R_2 of the variable resistor at this setting.

....

....

What value would you expect to get for R_2 when $V_2 = \frac{1}{4}E$?

....

....

(3)

(vi) Suggest three reasons why your experimental values of R_1 and R_2 differ from the expected values.

....

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....

(3)

(b) (i) Determine accurate values for the internal diameter d_i and the external diameter d_e of the washer provided. State any special precautions which you took to ensure that the diameters were as accurate as possible.

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....

(5)

(ii) Determine an accurate value for the thickness t of the washer.

....

....

....

(2)

(iii) Calculate the volume V of the washer given that

$$V = \frac{1}{4}\pi(d_e^2 - d_i^2)t$$

....

....

Using the top pan balance measure the mass m of the washer.

m = ...

Hence determine the density of the material from which the washer is made.

....

....

....

....

(3)
(Total 24 marks)

28. (a) Use the principle of moments, with the metre rule and the other apparatus provided, to find the mass m_0 of the matchbox and string, in grams. Draw a diagram to explain how you did this and show all your results and calculations in the space below. If you are unable to do this you should ask for the card from the Supervisor. You will lose 4 marks but you need not draw the diagram.

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(7)

(b) Put a mass of 60 g into the matchbox. Place the matchbox near the top of the slope provided and increase the angle α of the slope until the matchbox just starts to slide. The coefficient of static friction, μ, between the matchbox and the slope is given by

$$\mu = \tan \alpha$$

Take measurements to determine the value of $\tan \alpha$ and hence a value for μ. Draw a diagram to show how you did this and record all your measurements and calculations in the space below.

....

....

....

....

....

....

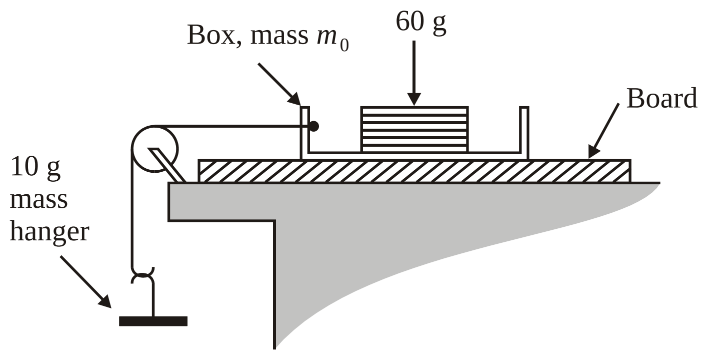
Assuming the uncertainty in μ is 0.02, what is the percentage uncertainty in your value?

....

....

(7)

(c) Keeping 60 g in the matchbox, set up the arrangement shown below, using the board from part (b).



Add masses to the hanger until the matchbox *just* begins to slide. Estimate the total mass m_s in grams needed for this to occur. Hence find a second value for μ given that

$$\mu = \frac{m_s}{M}$$

where $M = m_0 + 60$ grams.

....

....

....

....

(3)

(d) Estimate the percentage uncertainty in your value for m_s, explaining how you did this.

....

....

....

(2)

(e) You are to plan an experiment to further investigate the equation in part (c). Your plan should include

(i) a description of the experiment to be performed,

(ii) a sketch graph showing the expected results,

(iii) an indication of how μ can be found from the graph.

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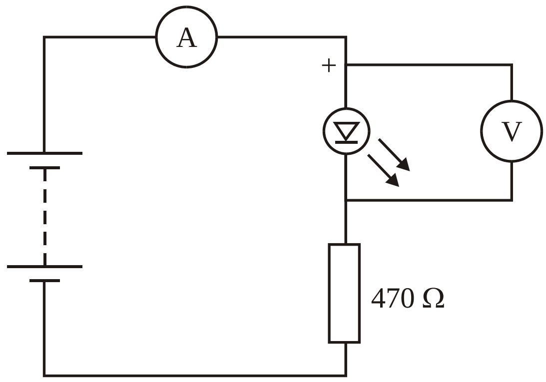
(5)
(Total 24 marks)

29. (a) (i) Set up the circuit shown in the diagram below. Use the red LED (light emitting diode). Before you connect your circuit to the power supply, have it checked by the Supervisor. You will be allowed a short time to correct any faults. If you are unable to set up the circuit, the Supervisor will set it up for you. You will lose no more than two marks for this.



(2)

(ii) Connect the circuit to the power supply. Record the potential difference V_r across the red LED and the corresponding current I_r.

V_r = ...

I_r = ...

Hence calculate the resistance R_r of the red LED in this circuit.

....

....

....

....

(3)

(iii) Replace the red LED with the green LED. Ensure that the positive end of the LED is connected as in the previous circuit. Record the potential difference V_g across the green LED and the corresponding current I_g.

V_g = ...

I_g = ...

Hence calculate the resistance R_g of the green LED in this circuit.

....

....

....

....

(3)

(iv) Repeat your measurements and calculations with the 220 Ω resistor connected into the circuit in place of the 470 Ω resistor.

1 Red LED with 220 Ω resistor

V_r' = ...

I_r' = ...

....

....

....

R_r' = ...

2 Green LED with 220 Ω resistor

V_g' = ...

I_g' = ...

....

....

....

R_g' = ...

(5)

(v) Write three conclusions based on your experimental observations.

....

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....

(3)

(b) (i) Determine an accurate value for the diameter d of the marble. Explain, with the aid of a diagram, how you tried to ensure that an accurate value for the diameter was found.

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....

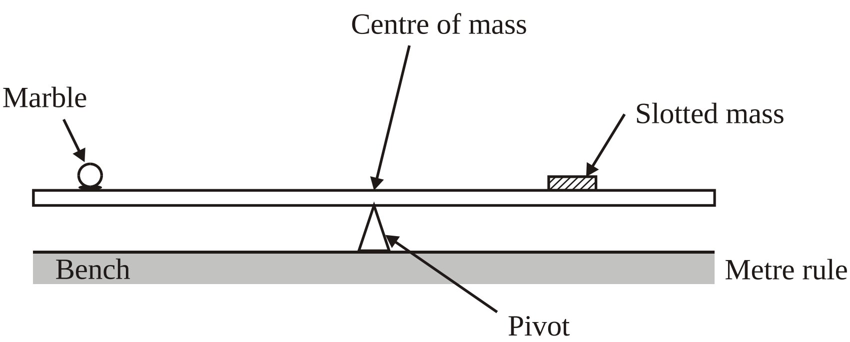
....

(3)

(ii) The metre rule has a small piece of Blu-tack attached to it at the 5 cm mark. Balance the rule on the knife edge to determine the position of the centre of mass of the rule and Blu-tack combination.

Scale reading at centre of mass = ...

(iii) Secure the marble to the metre rule at the position of the Blu-tack. Set up the arrangement shown in the diagram below.



Determine the mass m of the marble using the principle of moments. Using the above diagram, show carefully the measurements which you took in order to determine the mass m. Record all your measurements and calculations in the space below. The slotted mass has a mass of 10 g

....

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....

....

(5)
(Total 24 marks)

30. (a) (i) Measure the thickness of the single coin.

....

Measure the thickness of the stack of coins.

....

Hence determine the number *n* of coins in the stack.

....

....

(4)

(ii) You are provided with a metre rule and knife-edge. Use the principle of moments to determine the ratio of the mass of the stack of coins to the mass of the single coin and hence a second value for *n*. Draw a diagram of the arrangement you used, showing carefully the distances you measured. Show all your measurements and calculations in the space below.

....

....

....

....

(6)

(iii) State **one** source of experimental error in **each** of these methods of determining *n*.

Error in method (i): ....

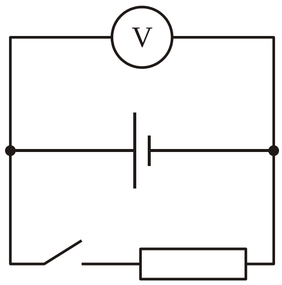
....

Error in method (ii): ....

....

(2)

(b) (i) Set up the circuit shown below, with the switch open and the multimeter set on the 20 V d.c. range.



If you are unable to set up the circuit ask the Supervisor. You will lose no more than 2 marks for this.

(2)

Record the e.m.f. ε of the cell.

ε = ...

Close the switch and record the potential difference V across the cell.

V = ...

Calculate a value for the internal resistance r of the cell given that

$$r = \left(\frac{\varepsilon}{V} - 1\right)R$$

where R = 10 Ω.

....

....

....

(2)

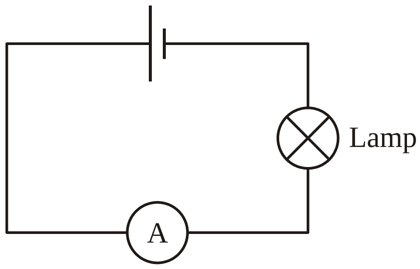
(ii) Disconnect the multimeter and set it to the 200 Ω range. If you are unable to do this ask the Supervisor. You will lose only 1 mark.

Use the meter to measure the resistance R_0 of the **lamp** when it is at room temperature.

R_0 = ...

(2)

(iii) Set the multimeter to the 2 A d.c. range and then set up the circuit below.



If you are unable to do this ask the Supervisor. You will lose only 1 mark. Record the current I in the lamp.

I = ...

Use the p.d. V that you found in part (i) to calculate a value for the resistance R_T of the lamp when it is glowing.

....

....

....

In view of the value you have obtained for R_T, discuss whether it is reasonable to use this value of V for the calculation.

....

....

....

(4)

(iv) Calculate the ratio $\frac{R_T}{R_0}$ and use the graph below to estimate the temperature T of the glowing filament.

....

....

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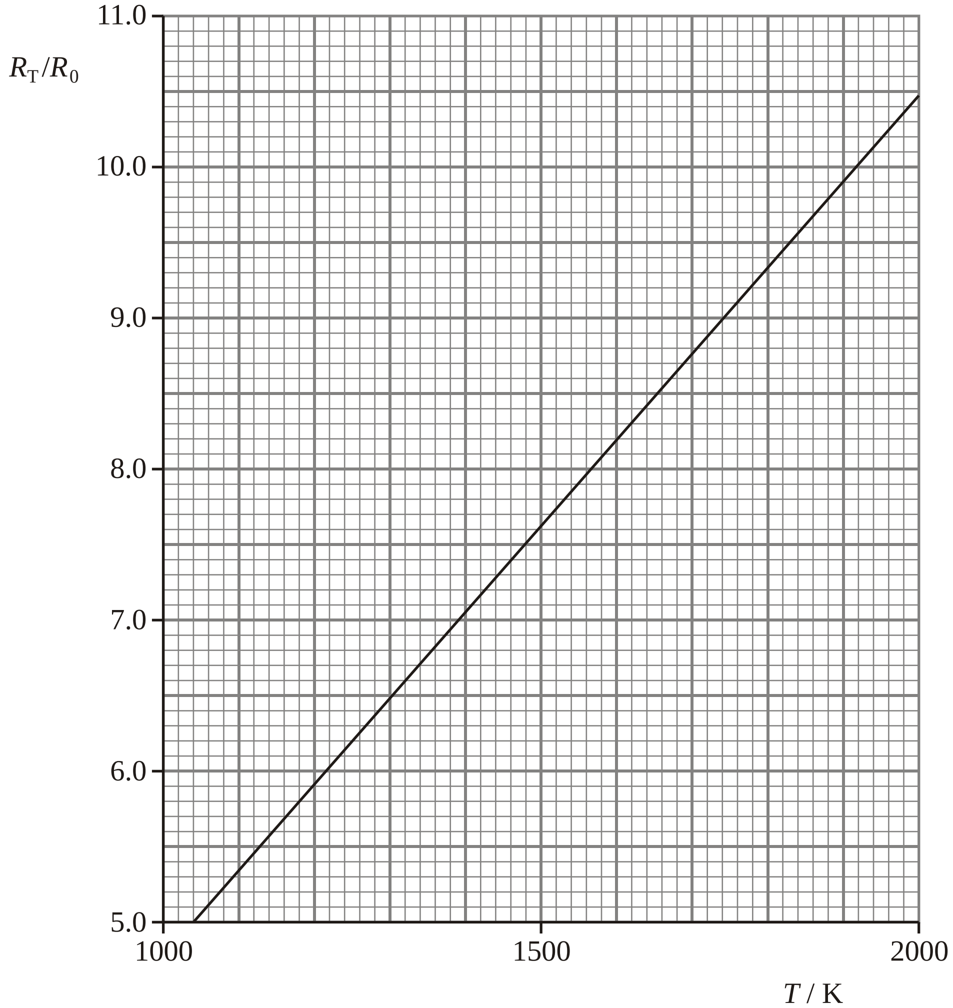

(2)
(Total 24 marks)

31. (a) (i) Place the 250 ml beaker on a heat proof mat. Pour water from the supply of boiling water up to the 75 ml mark on the 250 ml beaker and place the thermometer in the water. When the temperature starts to fall start the stopwatch and record, in the table below, the temperature θ_1 as a function of the time t for a period of 5 minutes. Add units to the headings of the columns of the table.

(ii) Repeat the above experiment using the 100 ml beaker rather than the 250 ml beaker. Fill the 100 ml beaker to the 75 ml mark from the supply of boiling water. Record your readings of θ_2 in the table below, adding the appropriate units.

Time *t*/	Temperature θ_1 of the water in the 250 ml beaker/	Temperature θ_2 of the water in the 100 ml beaker/

(6)

(b) Plot a graph of θ_1 against *t* on the grid below. Label this graph A.

On the same axes plot a graph of θ_2 against *t* on the grid below. Label this graph B.

(4)

(c) Determine the gradient of graph A at a **temperature** which is common to both graphs.

....

....

....

....

(4)

(d) A student suggests that the rate of fall of temperature at a given temperature is directly proportional to the area of the surface of the water, provided there is no loss of heat from the sides and base of the beaker. Plan an experiment to investigate this suggestion. Your plan should include:

(i) a description of the experiment to be performed,

(ii) sketches of any graphs you would plot,

(iii) an explanation of how the results would be analysed.

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(10)
(Total 24 marks)

32. (a) (i) Measure the length l and the width w of the aluminium foil. State any special precaution that you took to ensure that accurate values of l and w were obtained.

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(4)

(ii) Fold the foil in half four times to create a total foil thickness of 16t where t is the thickness of the foil. Measure 16t and hence determine t. State any special precautions that you took to ensure that an accurate value of 16t was obtained.

....

....

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....

....

(4)

(iii) Estimate the percentage uncertainty in your value for t.

....

....

....

(2)

(iv) Using the top pan balance provided, measure the mass m of the foil. Hence determine a value for the density of the foil.

....

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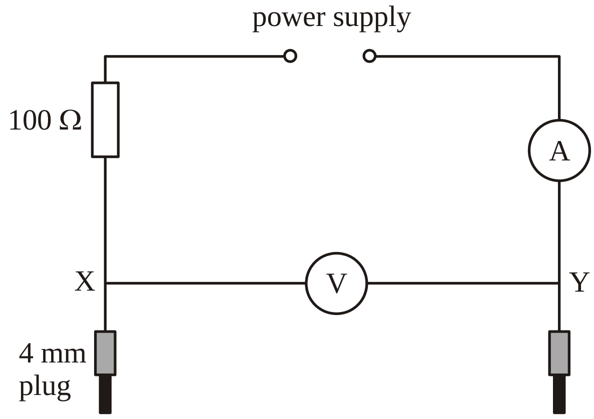
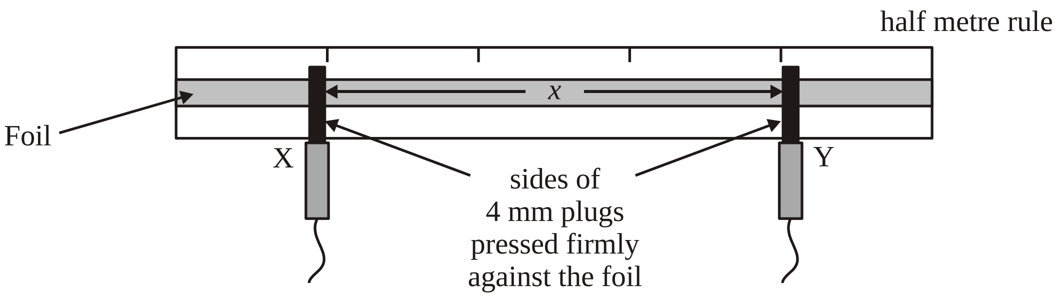
(3)

(b) (i) Set up the circuit as shown in the diagram below using the 100 Ω resistor. Before you connect your circuit to the power supply, have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults. If you are unable to set up the circuit, the Supervisor will set it up for you. You will lose only two marks for this.



(2)

(ii) Connect the power supply and use the 4-mm plugs to make connections to a length $x = 30.0$ cm of the strip of foil which is attached to the half metre rule. In order to make good electrical contact with the foil the **sides** of the 4-mm plugs should be pressed **firmly** against the foil as shown in the diagram below.



Measure the current I in the circuit and the potential difference V across the 30.0 cm length of foil.

I = ...

V = ...

(3)

(iii) Hence calculate the resistance R of the foil.

....

....

(2)

(iv) Determine an average value for the width b of the foil. Hence determine a value for the resistivity ρ of the foil given that $\rho = \dfrac{Rbt}{x}$.

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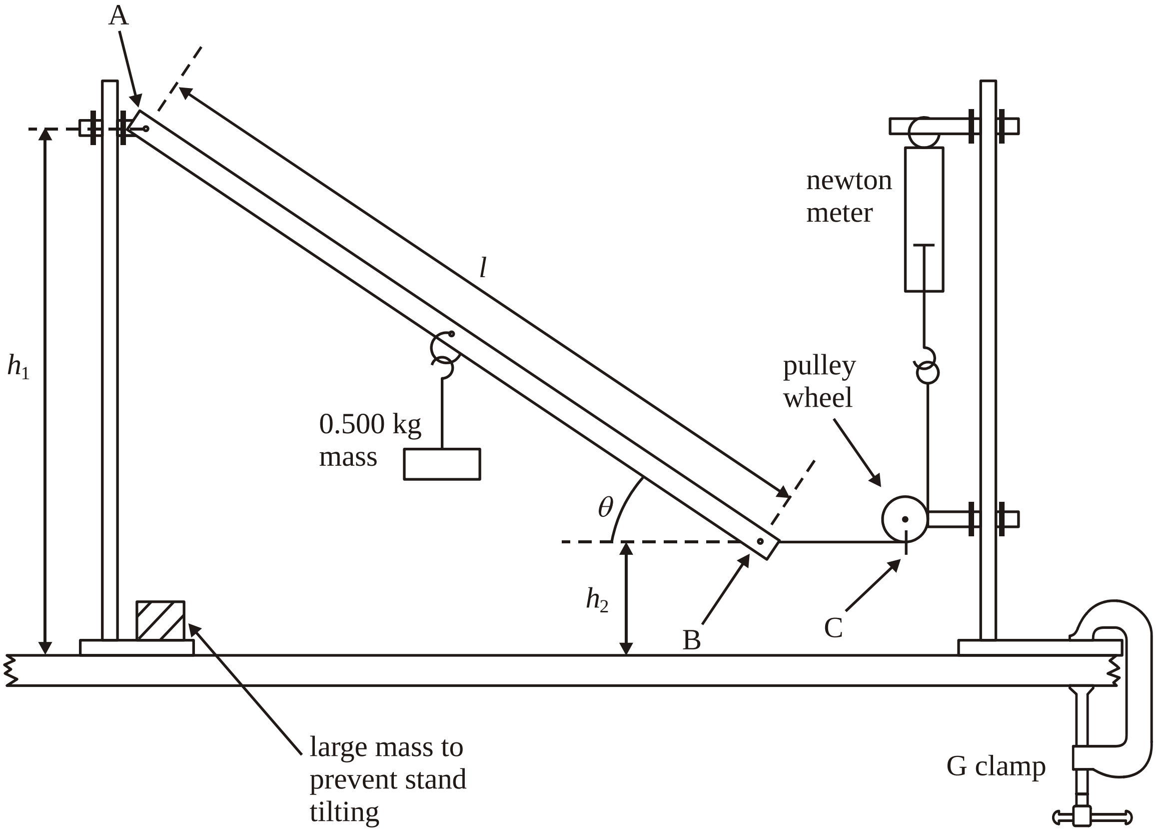
(4)

(Total 24 marks)

33. (a) The Supervisor has set up the apparatus shown in the diagram below. The newton meter is clamped vertically but the Supervisor has not made the section BC of the string horizontal.



Do not move the stand that is clamped to the bench. Adjust the separation of the stands and the height of the nail at A until the section BC of the string is horizontal and the angle θ is between 20° and 40°. You have been provided with a 30° set square so that you can easily estimate an angle in this range. Explain how you checked that BC was horizontal. You may add to the above diagram if you wish.

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(2)

(b) Measure the vertical height h_1 of the point A above the bench and the vertical height h_2 of the point B above the bench. Also record the distance, l, between the points A and B. Hence blank calculate a value for the angle θ using:

$$\sin\theta = (h_1 - h_2) / l$$

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(4)

(c) If the string is horizontal the principle of moments may be used to show that

$$W = 2T\tan\theta - mg$$

where W = the weight of the metre rule,
T = the reading on the newton meter,
m = the mass which is suspended from the rule, which may be taken as 0.500 kg,
and g = the gravitational field strength.

Record T.

T = ……………………..

Hence, using your result from part (b), calculate the weight of the metre rule.

....

....

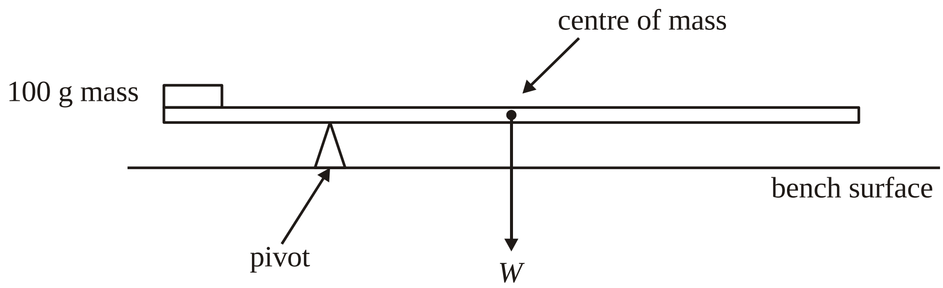
....

....

Weight = ...

(4)

(d) Set up the apparatus as shown in the diagram below using the second metre rule, which is identical to the suspended rule. Use one of the 100 g masses from the first experiment. Adjust the position of the pivot so that the system rests in equilibrium with the metre rule horizontal.



The centre of mass of the rule may be taken to lie at the 50.0 cm mark. Take such measurements as are necessary to find the weight *W* of the rule. **Show these measurements on the diagram.**

Now use the principle of moments to calculate *W*.

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(5)

(e) The equation in part (c) may be rewritten in the form

$$T \tan \theta = \frac{1}{2}mg + \frac{1}{2}W$$

A student suggests that the value of W may be found by a graphical method if the value of m is varied. Plan an experiment to investigate this suggestion. Your plan should include

(i) a description of how the experiment would be performed;

(ii) a sketch of the graph to be plotted;

(iii) how you would use the graph to find a value for W.

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(9)
(Total 24 marks)

34. (a) (i) You have been provided with a 4.0 m length of constantan wire which has the same diameter as the constantan wire which is attached to the metre rule. Using the top pan balance provided, measure the mass m of the 4.0 m length of wire.

m = ...

Carefully separate the turns of the 4.0 m length and measure the diameter d of the wire. State any precautions that you took to ensure that an accurate value of d was obtained.

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(3)

(ii) Estimate the percentage uncertainty in your value for d.

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(2)

(iii) Determine a value for the density of constantan given that

volume of wire = $V = \frac{\pi d^2 l}{4}$

where l = length of wire = 4.0 m.

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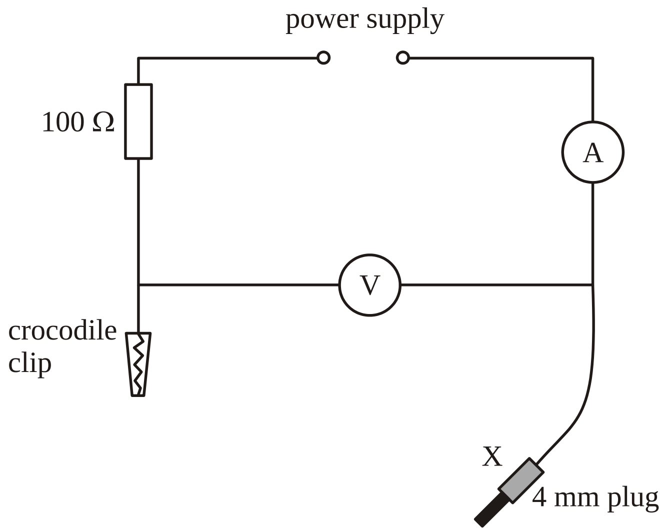
(5)

(b) (i) Set up the circuit as shown in the diagram below using the 100 Ω resistor. Before you connect your circuit to the power supply, have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults. If you are unable to set up the circuit, the Supervisor will set it up for you. You will lose only two marks for this.



(2)

(ii) Connect the crocodile clip to the wire at the zero end of the rule. Connect the power supply and use the 4-mm plug labelled X to make a connection to the wire at the 20.0 cm mark. To make good electrical contact the 4-mm plug should be pressed **firmly** against the wire.

Measure the current I in the circuit and the potential difference V across the 20.0 cm length of wire.

I = ...

V = ...

(3)

(iii) Hence calculate the resistance R_1 of a 20.0 cm length of wire.

....

....

(2)

(iv) Repeat parts (ii) and (iii) to find the resistance R_2 of an 80.0 cm length of wire.

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(3)

(v) Use your results from parts (iii) and (iv) to determine the resistance R of a length x = 60.0 cm of wire, where $R = R_2 - R_1$. Hence determine a value for the resistivity ρ of the wire given that $\rho = \dfrac{R\pi d^2}{4x}$.

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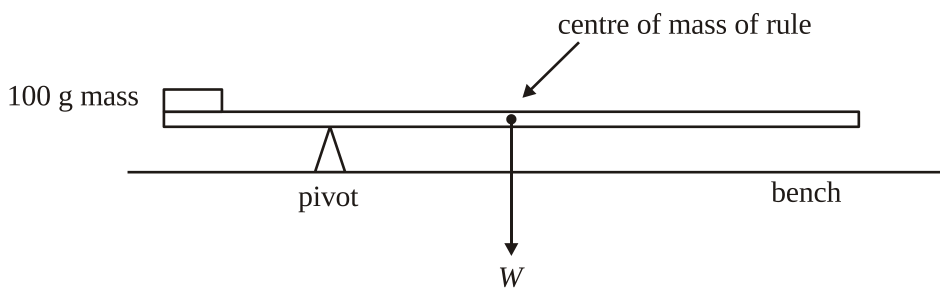
(4)
(Total 24 marks)

35. (a) Determine the position of the centre of mass of the metre rule labelled X by balancing it on the pivot so that it is approximately horizontal.

Position of centre of mass = ...

(1)

(b) Set up the apparatus as shown in the diagram below using the metre rule labelled X. The system should rest in equilibrium with the metre rule approximately horizontal.



Take such measurements as are necessary to find the weight W of the rule. **Show these measurements on the diagram.**

Now use the principle of moments to calculate W.

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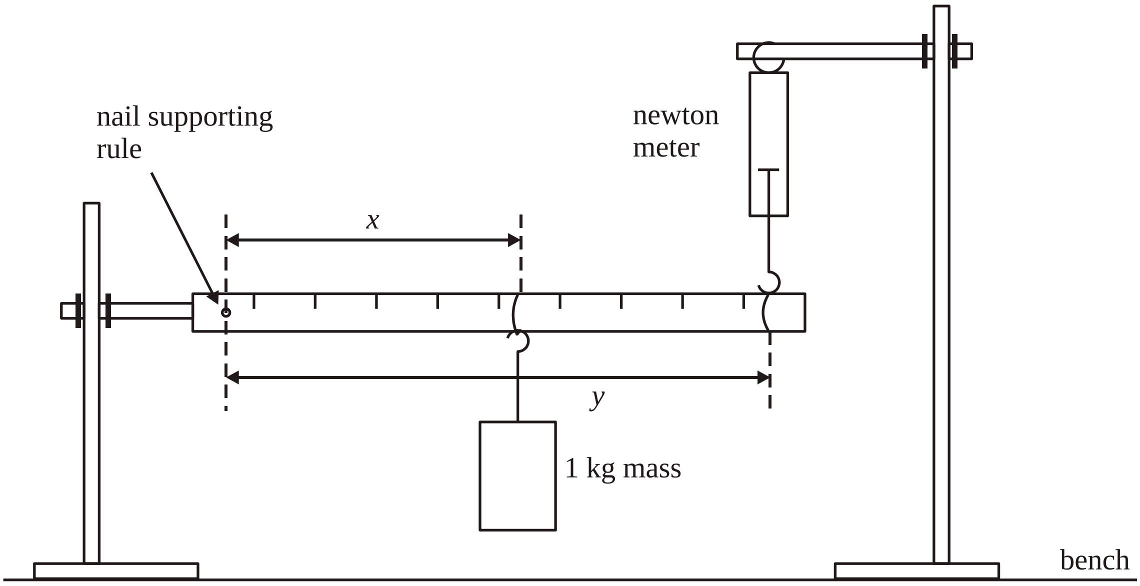
(6)

(c) Set up the apparatus as shown in the diagram below using the metre rule labelled X with the nail passing through the hole at the 1.0 cm mark. The loop of thread from which the 1.00 kg mass is suspended should be placed in the position of the centre of mass of the rule.



Adjust the height of the newton meter until the metre rule is horizontal. Explain how you ensured that the rule was horizontal. You may add to the above diagram if you wish.

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(2)

(d) By applying the principle of moments to the horizontal rule it can be shown that:

$$(W + mg)x = Ty$$

where W = the weight of the metre rule,
mg = weight of the 1.00 kg mass = 9.81 N,
T = the reading on the newton meter,
and x and y are the lengths shown in the diagram.

Record the reading on the newton meter and determine values for x and y. Hence calculate a second value for W.

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(4)

(e) Calculate the percentage difference between your two values for W.

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Which value of W do you consider to be more accurate? Give a reason for your answer.

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(3)

(f) A student wishes to investigate how the force supporting the rule varies with the distance of the newton meter from the nail. The equation in part (d) may be rewritten in the form

$$T = \frac{(W + mg)x}{y}$$

You are to plan this investigation. Your plan should include

(i) an indication of the values in the equation which would need to be kept constant;

(ii) a description of how the experiment would be performed;

(iii) a sketch of the graph to be plotted;

(iv) an indication of the expected results.

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(8)
(Total 24 marks)