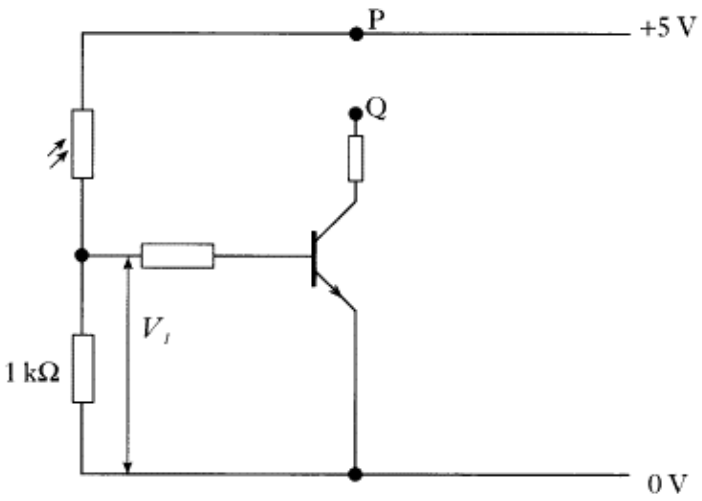
	Marks	K&U	PS

1. A pupil is asked to devise a circuit which will switch on automatically a light emitting diode (LED) when a room becomes dark.

Part of the circuit the pupil sets up is shown in the diagram below.



(a) Copy and complete the circuit diagram above to show a LED correctly connected between P and Q. **1**

(b) The properties of the light dependent resistor (LDR) in the circuit used by the pupil are shown in the table below.

Lighting conditions	*Resistance of LDR*
Bright	100 Ω
Dark	10 kΩ

V_1 is the input voltage to the transistor. The transistor switches on fully when V, rises above 0.7 V.

i) Calculate the value of the input voltage V_1 in dark conditions. (Use an appropriate number of figures in your answer.) **3**

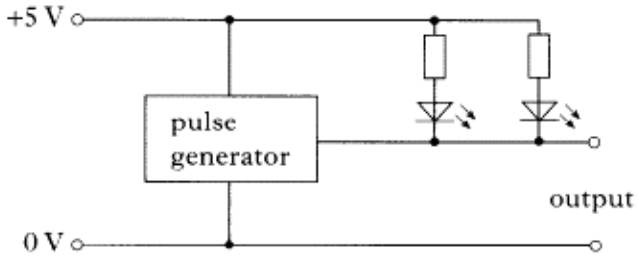
ii) When the room is dark and the LED is correctly connected it will **not** light. Explain. **2**

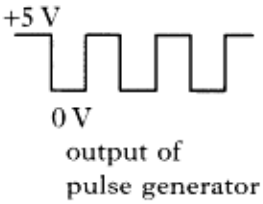
(c) Using only the components shown in the circuit diagram, state one change which should be made to the circuit to make it operate properly. **1**

2. A model of a black cat with flashing eyes is made for a Halloween party.

Marks	K&U	PS

Two LEDs which are used as the eyes are connected to a pulse generator as shown in the diagram below. The output of the pulse generator varies as shown.





(a) What is the voltage across the output of the pulse generator when the LEDs are lit? **1**

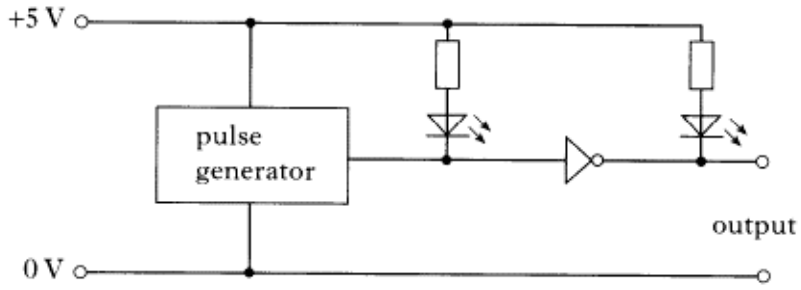
(b) A resistor is connected in series with each LED.

i) State the purpose of this resistor. **1**

ii) When lit, each LED has a voltage of 2 V across it and a current of 15 mA in it.

Calculate the value of the resistor in series with the LED. **3**

(c) The diagram below shows a change that was made to the circuit.

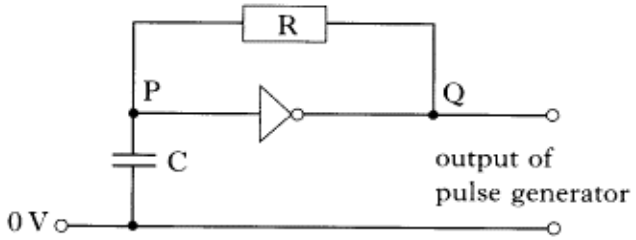


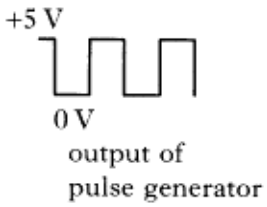
i) Name the component that has been added to the original circuit. **1**

ii) What effect does this change have on the operation of the LEDs in the circuit? **1**

Marks	K&U	PS

(d) The pulse generator circuit is shown in the diagram below. The power supply has not been included in this diagram.





Copy and complete the table to show the voltage at P and at Q when the capacitor in the pulse generator is charged and when it is uncharged.

Capacitor condition	*Voltage at P (V)*	*Voltage at Q (V)*
charged		
uncharged		

2

	Marks	K&U	PS

3. Figure 1 shows a conveyor belt in a supermarket. The belt is driven by a motor.

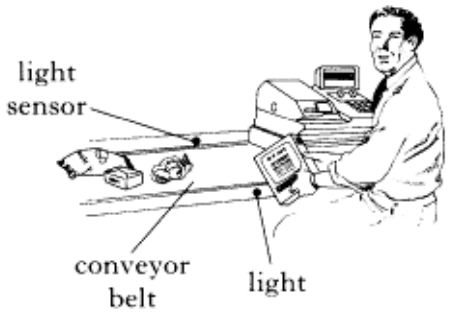


figure 1

Part of the mechanism which operates the motor uses a light-sensitive switch. The conveyor belt stops when a package comes between the light and the light sensor.

(a) The light-sensitive part of the system is shown in figure 2.

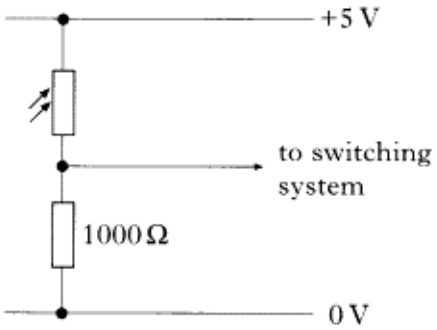


figure 2

The resistance of the light dependent resistor (LDR) in different lighting conditions is shown in the table below.

Lighting condition	*Resistance of LDR*
Light	100 Ω
Dark	10 000 Ω

Calculate the voltage across the 1000 Ω resistor when the LDR is in darkness. **2**

	Marks	K&U	PS

(b) The conveyor belt motor is connected to the light sensor using a transistor and relay as shown in figure 3.

The transistor switches off when the voltage across the 1000 Ω resistor drops below 0.7 V. The relay switch is used to switch the motor on and off.

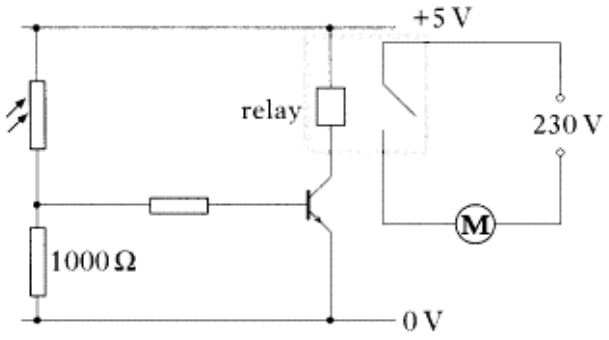


figure 3

Figure 4 shows the construction of the relay switch.

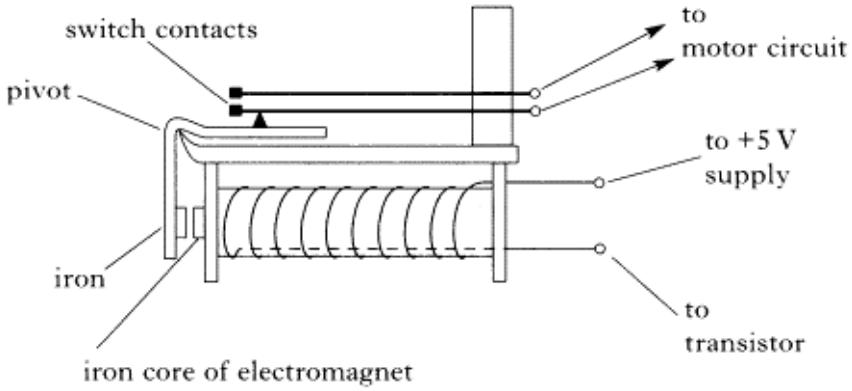
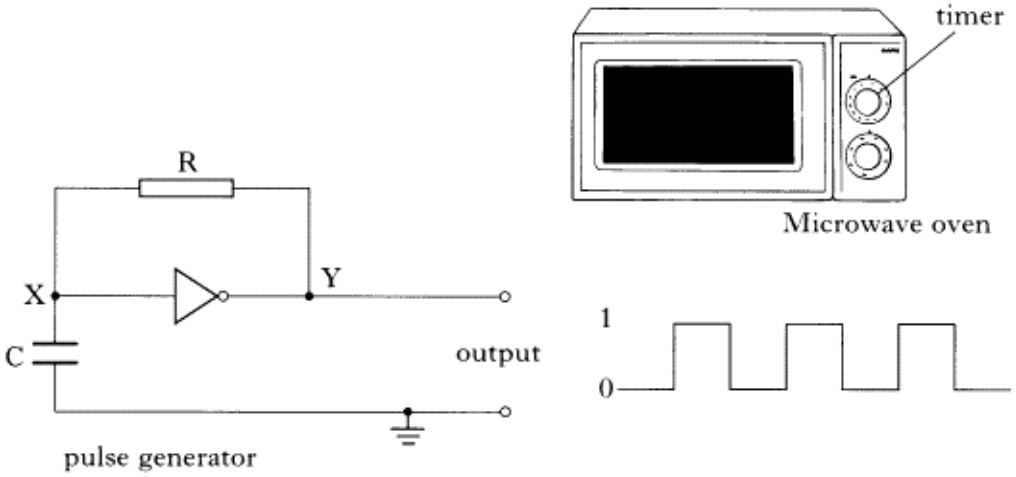


figure 4

Explain why the conveyor belt stops when a package comes between the light and the light sensor. **3**

Marks	K&U	PS

4. The timer in a microwave oven uses a circuit which produces pulses. The part of the circuit which generates the pulses is shown below. The voltage supply has not been included in the diagram.



(a) Copy and complete the table below to show the logic levels at X and Y when the capacitor in the circuit is charged and when it is uncharged.

	Logic level at X	*Logic level at Y*
Capacitor charged		
Capacitor uncharged		

2

(b) The output from the above circuit is connected to a counter and a seven segment display.

At what frequency should the pulses be generated for the seven segment display to change every second?

1

(c) When tested, the timer was found to run slowly.

What change should be made to the circuit to correct this fault? Explain your answer.

2

	Marks	K&U	PS

5. The diagram below shows an automatic hand washing unit in a restaurant.

figure 1

Inserting the hands into the unit breaks a light beam and causes a stream of water to be turned on for ten seconds.

(a) The light beam is directed at a light dependent resistor (LDR) which is part of the circuit shown in figure 2.

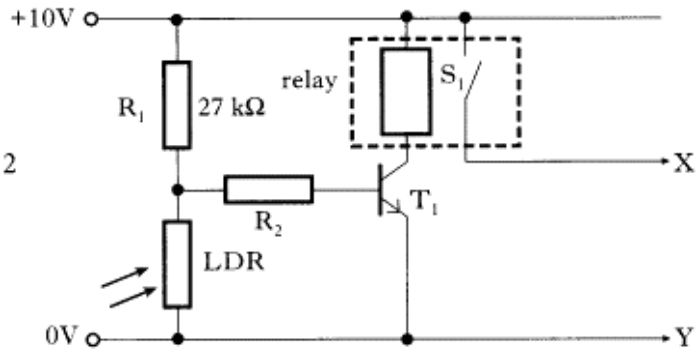


figure 2

i) When hands are inserted into the unit, the circuit in figure 2 causes the switch S_1 in the relay to close. Explain why this happens. **3**

ii) Calculate the voltage across the LDR when its resistance is 9.0 kΩ. **2**

(b) When the relay switch in figure 2 is closed, another circuit connected to X and Y as shown in figure 3 opens a water valve for ten seconds.

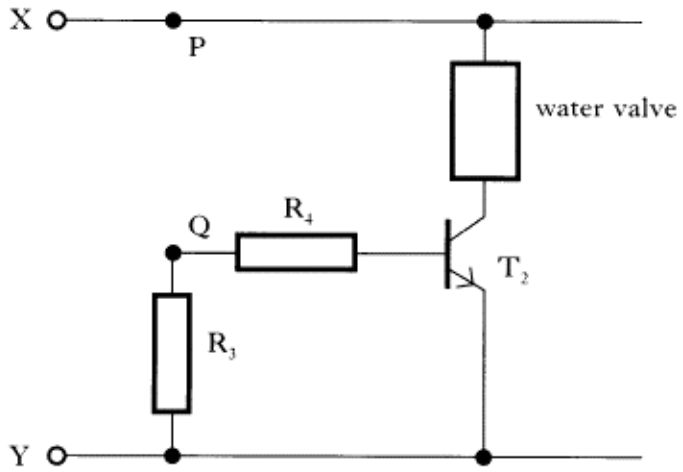


figure 3

Copy and complete the diagram in figure 3 to show the component which should be connected between P and Q so that the water is turned on for ten seconds. **1**

	Marks	K&U	PS

6. Traffic engineers use metal loops to detect the number of vehicles travelling along a road. The loops are buried under the road surface. When a vehicle passes over a loop, a single digital pulse is sent to a control circuit. The diagram below shows a situation where traffic must move in single file on each side of a road. Loops X and Y are buried under each side of the road at the positions shown.

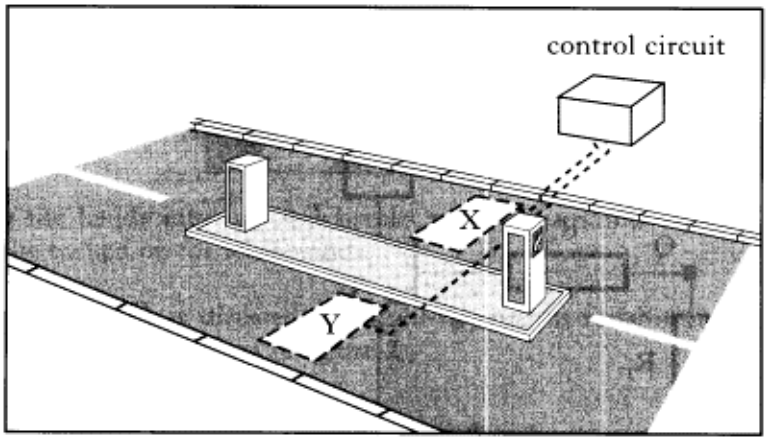


figure 1

(a) Part of the control circuit is shown in figure 2.

During the time a vehicle passes over loop X, the logic level at P changes from logic 0 to logic 1.

During the time a vehicle passes over loop Y, the logic level at Q changes from logic 0 to logic 1.

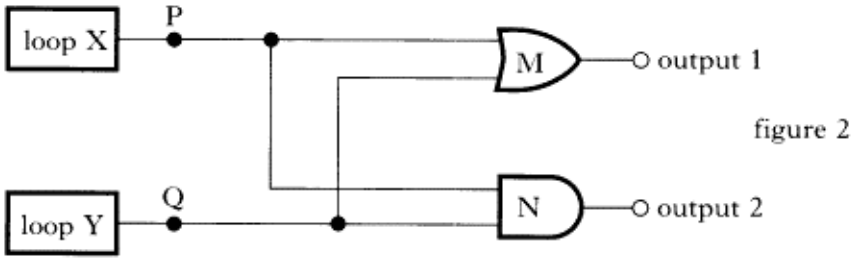


figure 2

i) Name logic gate M. **1**

ii) Name logic gate N. **1**

iii) Copy and complete the truth table below for this part of the circuit.

Input P	*Input* Q	*Output 1*	*Output 2*
0	0		
0	1		
1	0		
1	1		

2

	Marks	K&U	PS

(b) The two outputs from the above circuit are displayed on a computer screen. The outputs observed over a one minute period are shown in figure 3.

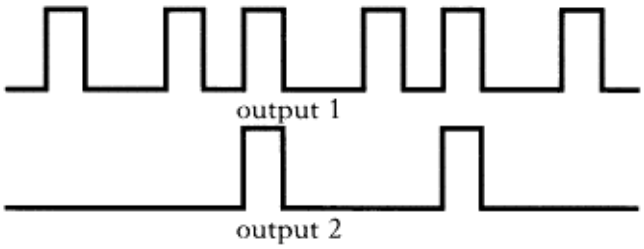


figure 3

i) Explain why more pulses are seen on output 1 than on output 2. **2**

ii) How often, during the period shown, were vehicles detected at the same time? **1**

iii) How many vehicles were detected during the period shown? **1**

(c) As shown in figure 4, a light emitting diode (LED) is connected across the 6 V supply of the control circuit, to indicate when the supply is switched on.

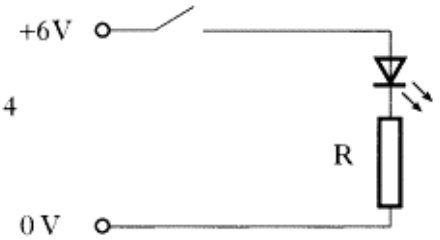


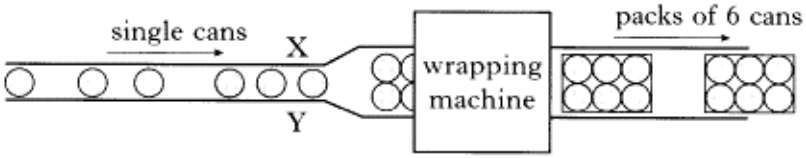
figure 4

When lit, the current in the LED is 20 mA and the voltage across it is 1.6 V.

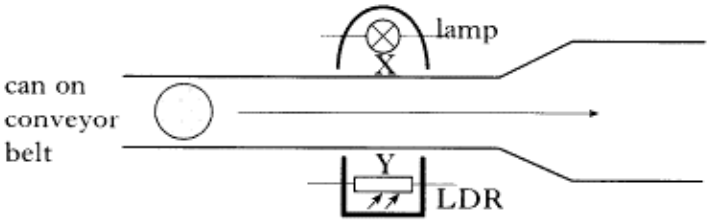
Calculate the resistance of the resistor R. **3**

	Marks	K&U	PS

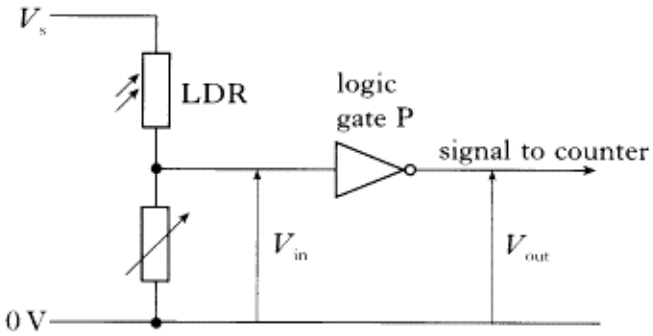
7. A factory wraps cans in packs of six. The cans travel in a single line along a conveyor belt to a wrapping machine which seals them in plastic.



A light beam is set up across X-Y to send a signal to a counter. This signal operates the wrapping machine after six cans are detected.



(a) The circuit shown produces the input signal for the counter.



i) What type of logic gate is P? **1**

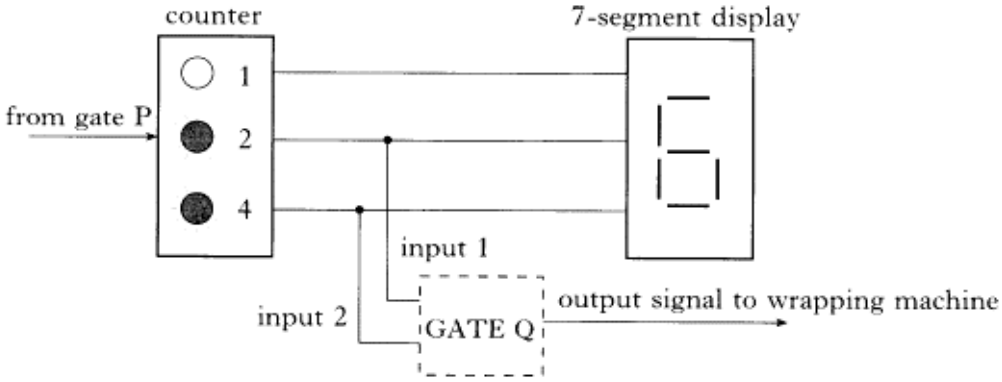
ii) Copy and complete the following table, writing either high or low for each entry, to show what happens as cans pass through the light beam.

	No can in light beam	*Can in light beam*
Light level at LDR		
Resistance of LDR		
V_{in}		
V_{out}		

4

	Marks	K&U	PS

(b) The output of gate P goes to the counter. A 7-segment display shows the number of cans at the wrapping machine. Part of this circuit is shown below.



i) **Copy** and complete each sentence below by choosing a word from the following list.

analogue **binary** **decimal**

The output of the counter circuit is .....

The output of the 7-segment display is .....

2

ii) Gate Q sends a signal to the wrapping machine when six cans have been detected.

(A) What type of logic gate is Q? **1**

(B) Copy and complete the truth table for gate Q.

Input 1	*Input 2*	*Output*
0	0	
0	1	
1	0	
1	1	

2

iii) There is a short delay to allow six cans to enter the wrapping machine before they are wrapped.

Name a suitable input device that could provide this delay. **1**