S&C June 2014 Model Answer

NB: With S&C papers, there are often multiple ways to answer a question and still achieve all the marks. This example shows the answers that I'd use if I was sitting the exam, sometimes with additional possible answers.

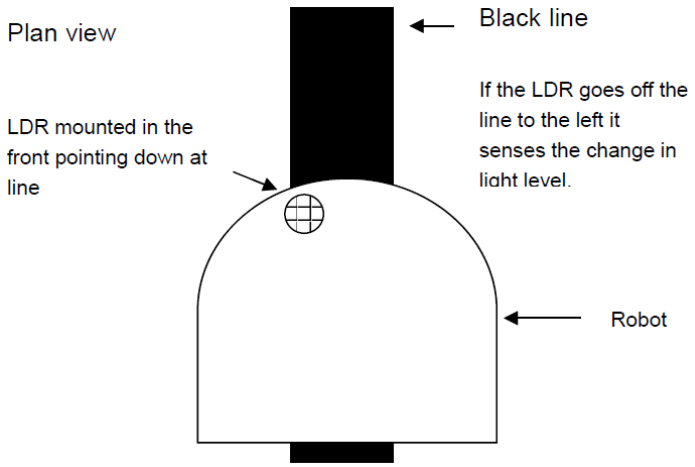
Key areas that attract marks are shown in bold where appropriate, to help you spot them, and teacher's notes have been included. Note that where a question might ask for two examples, I've often given more to show some alternative answers you could consider.

1a. Specification points…
Power specification point: The unit must run on batteries.
Justification: It will need to be able to move freely and not have a cable that can become tangled.
Aesthetic specification point: The housing should look like an animal.
Justification: If it looks attractive, customers will be more likely to buy it.

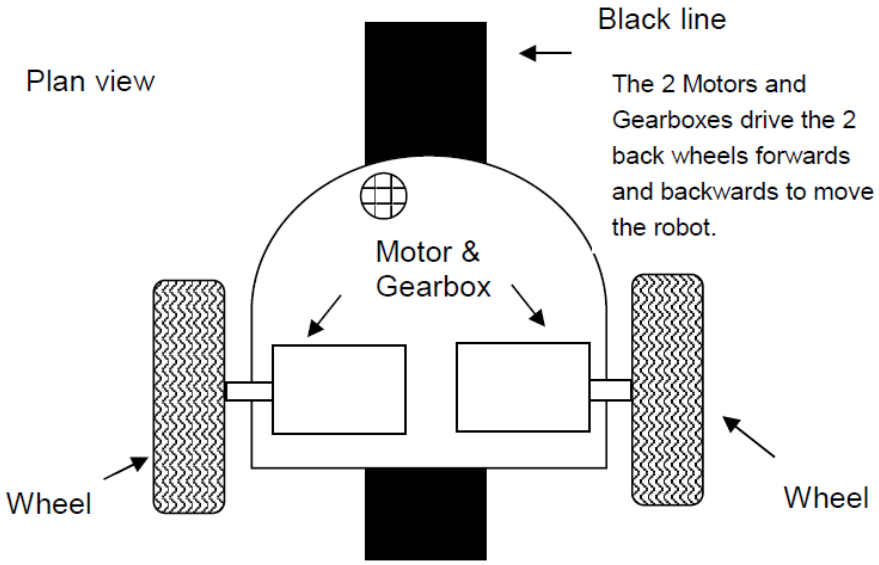
Teacher's notes: As there are two marks for each of these, I made sure that I said what each requirement was, and then explained why it was important.

1b. Input: LDR
Process: PIC
Output: DC motors

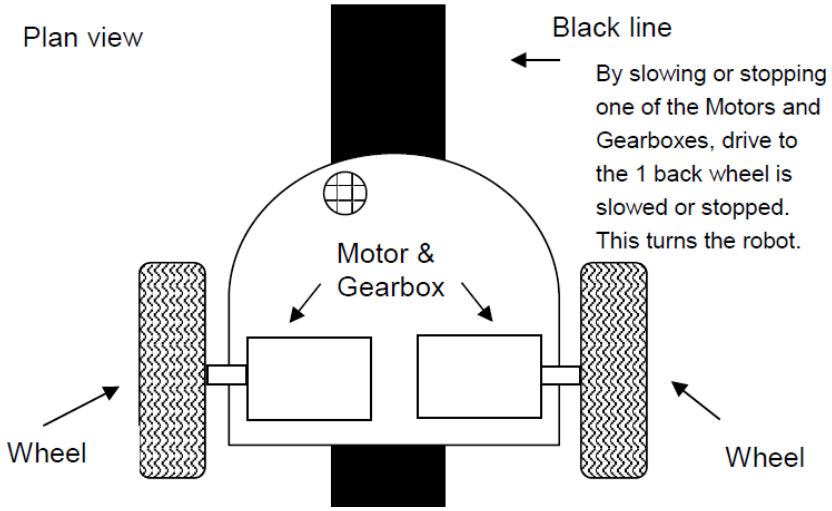
1c. i.



1c. ii.



1c. iii.



2. a. Feedback is where the output of a system is sent back into the system itself.

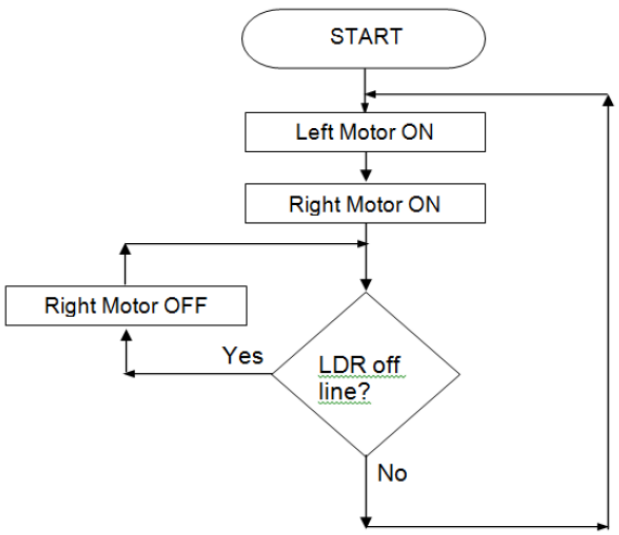
2b. i. Feedback is used advantageously in central heating systems. The output from the heating system (i.e. heat from the radiators) is detected by the input to the system (i.e. the thermostat on the wall). This allows the process (the heating control panel) to decide whether to keep the boiler running because the temperature is too low, or turn it off because the temperature is too high. A greenhouse with an automatically

2b. ii. In a PA or Karaoke system, feedback can be a problem. It occurs when the output (sound from the speaker) is picked up by the input (the microphone), which then is processed (by an amplifier). This causes a high-pitched scream, which is uncomfortable for the audience.

2c. By having an LDR mounted near the line, when the unit is on the line, less ambient light will be reflected onto the LDR as it'll be absorbed by the line.

When it comes off the line, the white background will cause more light to be reflected up. This feedback can be used by the PIC to make decisions on how best to navigate the line by turning motors on/off.

2d.



3a.

No.	Component image		
1		LED	Output
2		Transistor	Process
3		Momentary switch	Input
4		DC motor	Output
5		Relay	Process
6		Buzzer	Output

3b. i. Thermistor

3b. ii. Variable resistor

3c. Formula: $V2 = (R2 / (R1 + R2)) \times V_s$ (*Note: From formulae on page 2*)

Calculation: $V2 = (20000 / (10000 + 20000)) \times 9$
$= (20000/30000) \times 9$
$= 2/3 \times 9$

Answer: V2 = 6V *(Note: You get a mark for including the V at the end)*

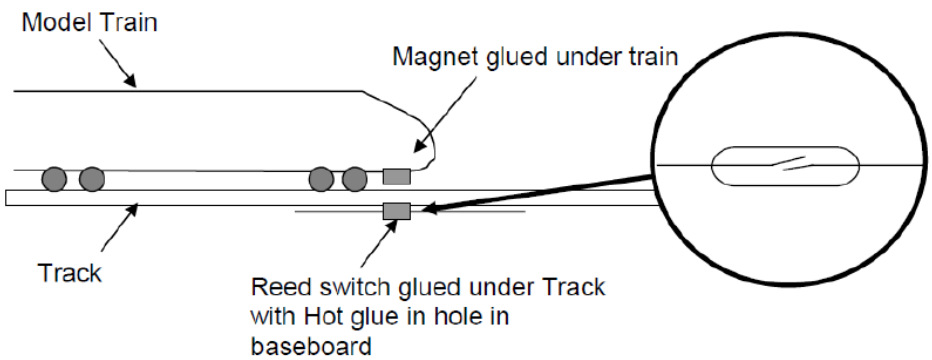
4a. i. Acrylic.

4a. ii. It is strong, easy to cut on a laser-cutter and available in lots of colours.

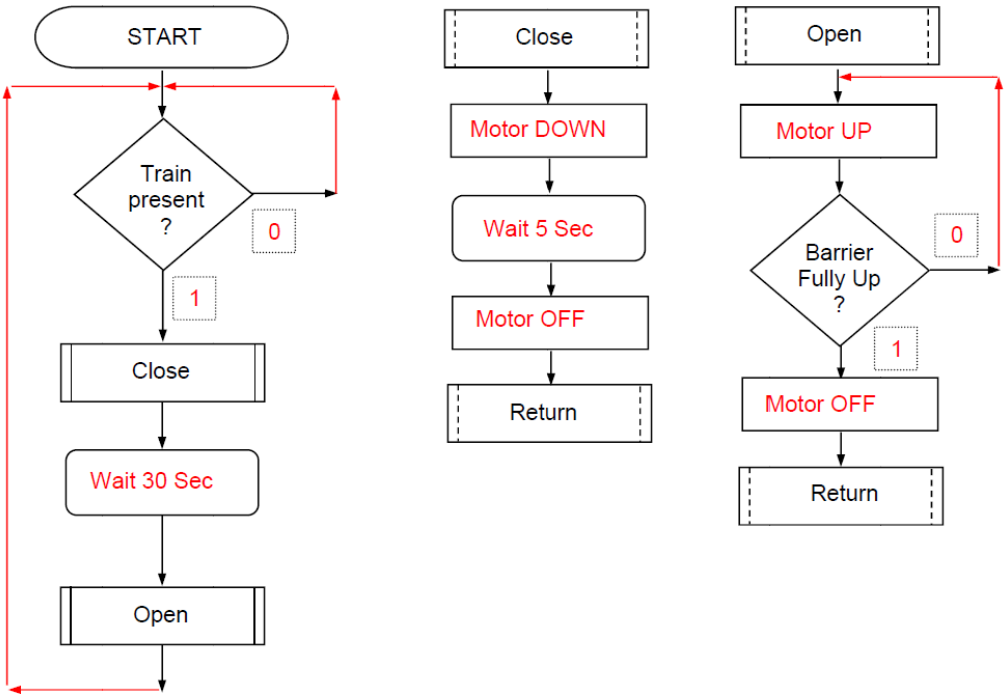
4b. i. A reed switch (*Note: I could use a microswitch or an LDR too*)

4b. ii. I'd stick a small magnet under the front of the train. When the train passes over the top of it, it will close the switch, which can be connected to a digital PIC input.

4b. iii.



4c.



5a. The circuit could be built on a breadboard. This would involve inserting components into a prototyping board, so that the circuit can be seen running exactly how it would if made as a PCB, but without the need to waste any components. If there are any problems, components can be quickly swapped in and out to get a working circuit.

Teacher's notes: I initially answered this question incorrectly, as I was rushing and didn't read the question being asked. I actually wrote the answer that I've since copied and pasted into 5e. Don't make my mistake! No matter how obvious the question, get into the habit of reading them twice, and thinking carefully about any key words in the question.

5b. Two advantages of CAD for designing PCBs:

Advantage 1: Changes to where tracks run can be made on the fly without needing to re-draw an entire artwork.

Advantage 2: Gaps between pads (e.g. for 20 pin ICs) can be created precisely, to ensure the components will fit into the PCB neatly.

Also…

Drawing on a computer is likely to be faster than drawing onto transparency paper by hand

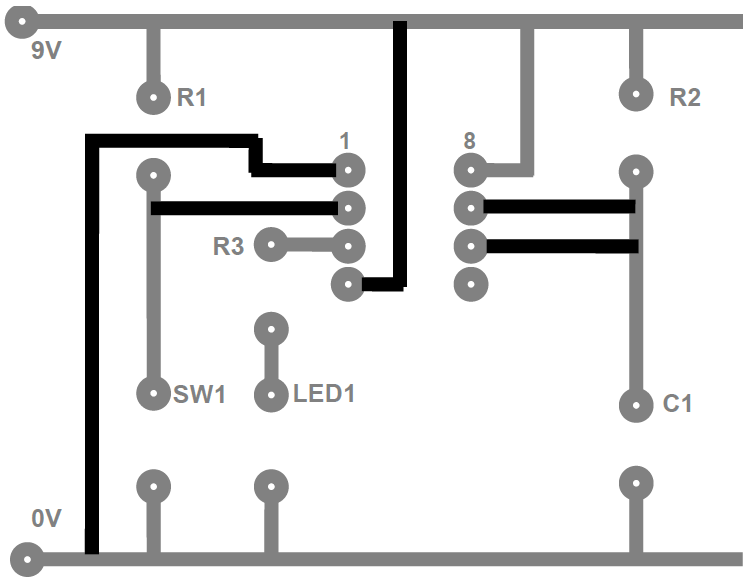
Tracks can be drawn more closely together, with less risk of them touching

CAD software may have circuit simulation facilities to give better confidence that a design will work when manufactured.

Teacher's notes: I didn't just say, 'its quicker', 'its better' or 'its neater'. I made sure that I justified what I was saying by comparing to something else (hand-drawing in this case).

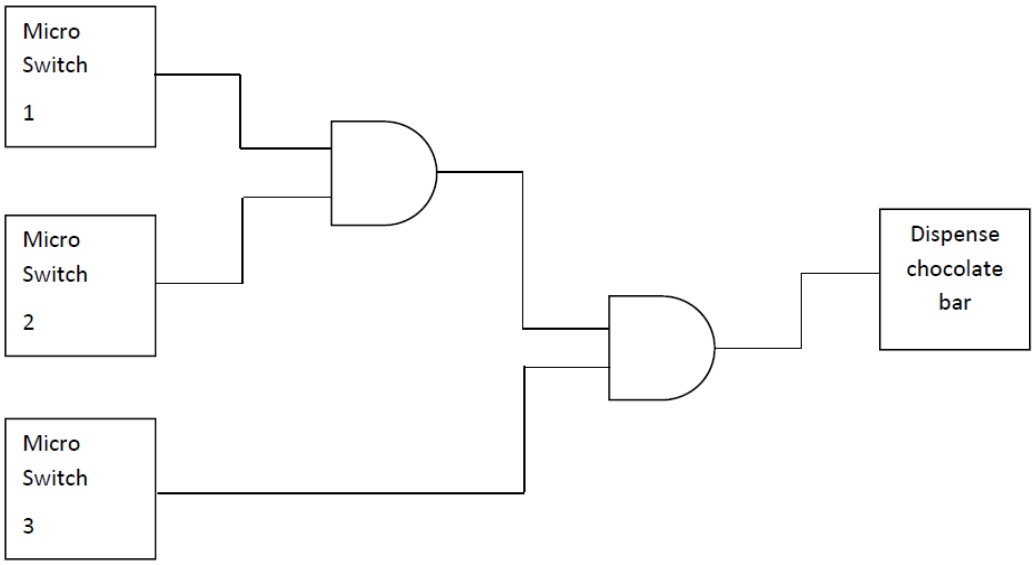
5c. Five main stages of PCB production
1. Printing artwork onto transparency paper and expose photoboard to UV light.
2. Photoboard goes into developer tank to wash away softened photoresist.
3. Photoboard goes into etch tank to wash away unprotected copper, then rinse.
4. Board tinned to protect copper tracks from oxidation.
5. Holes drilled using precision drill.

5d.



5e. I could use the continuity setting on a multimeter. This tells me if two points on the PCB are directly electrically connected. Where I have concerns that two tracks may have merged together during the etching process, I can use this setting to determine whether they're separate or not. I could also check that there is a clear path from my 0V input to the 0V connection on components such as my PIC.

6a.



6b. i. Linear.

6b. ii. A solenoid provides around 10mm of linear motion, are compact and fairly reliable components (as long as they're not energised for so long that they overheat). They are also easy to integrate into a circuit, as they can usually be driven from a transistor.

6b. iii. Solenoids tend to have high current and voltage requirements (often 12V, 1A) and as such will quickly drain small-capacity batteries. Also, 10mm isn't a lot of movement.

6c. A tilt switch or mercury switch could detect tipping. Alternatively, a microswitch located under the base of the machine, which would be released when the machine is tipped.

6d. Method 1: 555 monostable timer. By choosing the desired capacitor and resistor values, a delay between fractions of a second and several days can be achieved.

Method 2: A PIC chip. A PIC program could be created to add a delay to the controlling flowchart program using a WAIT or PAUSE command.

6e. Issue 1: There should be no exposed wires, to reduce the risk of electric shock by users.

Issue 2: The unit should be designed so as not to be able to trap the user's hand/arm when extracting drinks.

6f. It could be argued that it is the user's fault if they topple a drinks vending machine onto themselves. At the same time, one might argue that the design of the drinks machines was partly to blame if the manufacturer hasn't taken reasonable precautions to prevent injury. As a result, there is a risk of the manufacturer being sued for damages, which will also cause bad publicity for the drinks company (regardless of whether they are found innocent/guilty). It is usually better for a company to prevent the tragedy occurring than win the legal battle following it.

The design of the vending machine could prevent this happening by simply having the ability to be bolted to the wall/floor or retained in place with a chain. Lowering the centre of gravity by putting concrete/lead blocks in the bottom of the unit would also help, although be less practical.

A tilt switch could be added to the unit to trigger a loud siren if shaken would also put potential machine-tippers off.

Teacher's notes: I'm not an expert on vending machine injury law. At the same time, I can make some educated remarks about it, and debate the issue a little in order to obtain 8 marks.