Electronics

Course Code: ELT315114

Question 1

Those students who answered did well. RCD were generally not well understood but most were able to obtain 1 mark.

a) $V_{peak} = 1.414 \times V_{RMS} = 339V$

b) R =V/I = 340/0.05 = 6800 R (or use R=7000R and solve for I < 0.05)

c) Fibreglass is poor conductor as opposed to Alumunium.

d) RCD compares outgoing current to return current and disconnects circuits when a significant difference is detected.

e) A fuse typically operates at a threshold well above 0.05A and will not trip until higher current has been reached.

Question 2

Not answered well. Students demonstrated little knowledge of capacitor types.

a) High current/power applications.

b) Inductive effects due to solenoid. Add a capacitor in series to reduce overall reactance.

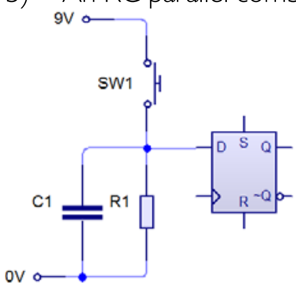
c) Tantalum is polarized, has a large capacitance for the component's size and is suitable for DC. Ceramic are not polarized and suit AC/audio/high frequency applications.

Question 3

Many students gave only one response to a. Many incorrectly thought that the 9V supply was problematic. De-bounce circuits not well done.

a) (i) No pull-down resistor, (ii) no de-bounce, (iii) possible synchronisation issues between switch and clock.

b) An RC parallel combination from D down to Earth will solve these problems.



Question 4

All students who attempted solution correctly chose the 2nd option. Many didn't give enough detail for full marks. In part b) most students gave 3+ steps although often the same idea was essentially repeated. Partial marks were given where detail was insufficient.

a) Student 2's solution is best because:
- Accurate control of SG inputs (freq. and amplitude)
- Oscilloscope gives more information such as signal distortion, frequency, amplitude, noise etc.
- Multimeter can be used to check supply voltage, biases, resistances etc.

b) Possible troubleshooting steps are:
- Visual inspection of track/solder joints
- Measurement of voltage levels.
- Use oscilloscope to trace signal from input through to output.
- Use multimeter to check continuity/resistance.
- Check component selection and polarity.

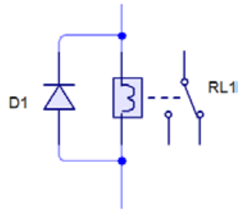
Question 5

About half of the students answered a) correctly. Few were able to give a full explanation of back emf although many were able to correctly answer parts c) and d).

a) Q1

b) When the voltage supply is disconnected from the relay the magnetic field generated by the solenoid collapses rapidly. This induces a current and a corresponding back emf across the inductor.

c) Diode needs to be in parallel with the relay and reversed biased.



d) The diode conducts when the transistor switches off, and the back EMF causes the voltage across the diode to rise above 0.7V. Under normal operation, the diode is in reverse bias so will not conduct. It provides a pathway for the induced current by the collapsing magnetic field in the relay to flow when the transistor is off.

Question 6

Many students seemed to guess at part a). Part b) well answered. Most students got 1 mark in part c) but were unable to connect the problem to the high impedance. Part mostly done well.

a) 1 – CMOS, 2- TTL, 3 – CMOS, 4- CMOS, 5 – CMOS, 6 – CMOS , 7 – TTL

b) Possible responses included:
- Discharge body static.
- Anti-static strap
- Keep IC in conductive foam
- Connect power pins first

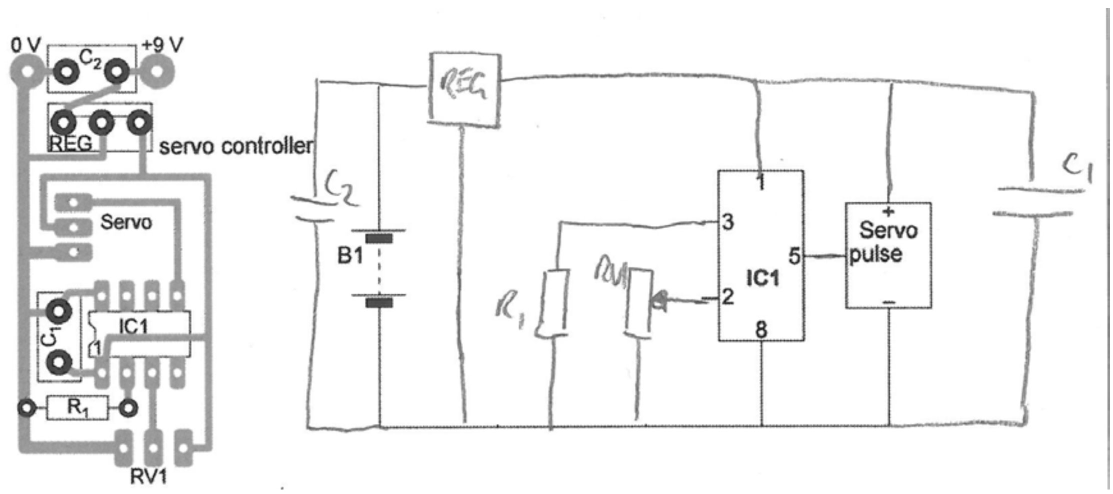
c) High impedance means that very small currents are sufficient to register a high on a floating input leading to false readings. Tying unused inputs gives a known input.

d) CMOS
- Advs – Less power and flexible voltage supply
- Dis – Slower and lower power output

Question 7

Half of students were able to draw circuit in part a) to a good standard. Few realised that the 7805 regulator outputs 5V. Most gave 4.5V instead of 2.5 in part c).

a)



b) To regulate the 9V supply into a 5V supply for the IC.

c) Half way position is a voltage divider that halves the voltage. ½ x 5 = 2.5V

d) Possible responses included:

- The PICAXE is reprogrammable/ modifiable via coding.
- The IC does not take up much space compared to logic circuits.
- Less components leads to a simpler circuit overall which can be more easily and cheaply designed and is easier to troubleshoot.

Part 1 Section B

Question 8

Mostly done well.

a)

pF Code	nF	uF
155	1500	1.5
393	39	0.039
474	470	0.47
222	2.2	0.0022

b)

Resistor Value	Closest E12	Colour Code
71R	68	Blue grey black
365 000	390 k	Orange white yellow

Question 9

Part a) mostly done well. Generally only one advantage given in part b). Part c) poorly done, few were able to identify the various OP AMP configurations.

a) Open Loop Gain – Infinite

   Output Impedance – Zero

   Input Impedance – Infinite

   Bandwidth – Infinite

b) Control gain in amplifiers
   Reduce open loop gain and avoid saturation
   Set reference voltage for a comparator

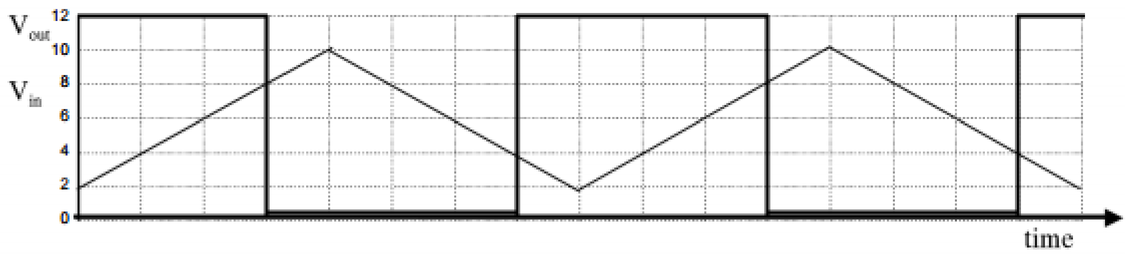
c)
   1) i) Voltage Follower ii) Input to (+) / No resistors / unity gain
   2) i) Inverting Amplifier ii) Input and Feedback resistors. Input to (-)
   3) i) Astable / Sig. Gen. ii) No input. RC feeback
   4) i) Non-inverting Amp ii) Input to (+). Negative feedback.

Question 10

Most students obtained two marks for a) but failed to explain the role of positive feedback. Few students knew what ½ meant in c). Very few could set up the effective resistor configurations required for part d). Only a few students obtained full marks, many obtained partial marks due to an incorrect inversion/shift of the graph.

a) Positive feedback in the circuit introduces a different threshold voltage for turning on (1) and off (0) the output of the op-amp.
b) R3 the positive feedback resistor.
c) ½ indicates the first of two op-amps packaged in the IC.
d) The two thresholds arise as the changing state of the op-amps output adjusts the effective resistor configuration of the voltage divider. When V_{OUT} is low then R3 should be drawn in parallel with R5. When V_{OUT} is high then R3 should be drawn in parallel with R4. The resulting voltage dividers give the correct values of 4V and 8V respectively.

e)

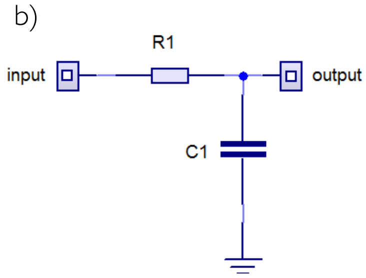


Question 11

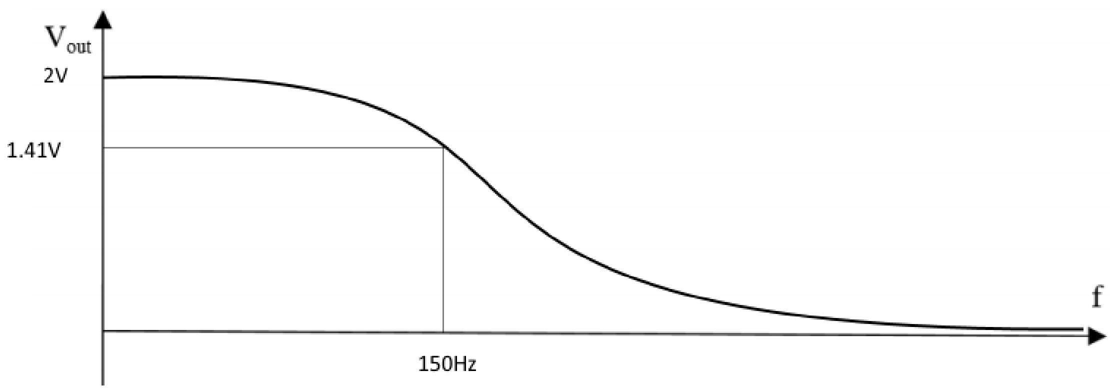
Parts a) done well. In part b) the passive filter was generally correct but the op-amp configurations often contained errors. Part c) mostly good. Part d) about half of students obtained correct answers, i) was done better than ii).

a) i) power supply is needed for active filter ii) Frequency response (roll-off) is better controlled in active filters.

b)



c)



d) i) $V_{OUT} = 2/1.414 = 1.414$ V ii) $P_{OUT} = \frac{1}{2} P_{IN} = 375$ W

Question 12

Part a) generally done well. Not many were successful with part b) although some obtained partial marks for grounding S and R and joining J and K. About half of the students did well in part c). Many completed the timing diagram as if for a counter.

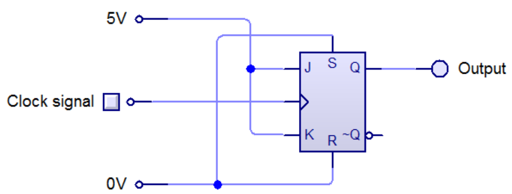
a)

i) Synchronous inputs affect the output only in synchronisation with the appropriate phase of the clock. Asynchronous can affect output at any time.

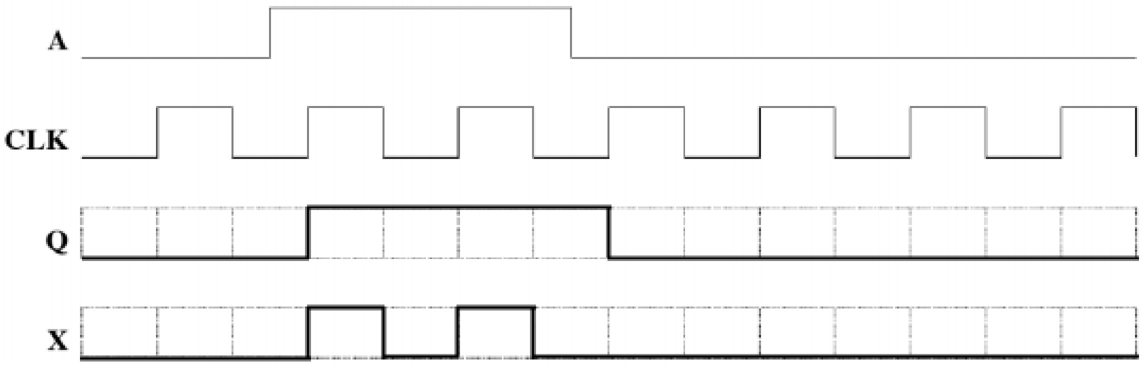
ii) S and R

iii) Positive Going Edge (PGE)

b) Connect J and K to V_+. Connect S and R to ground. Input goes to clock.



c)



Question 13

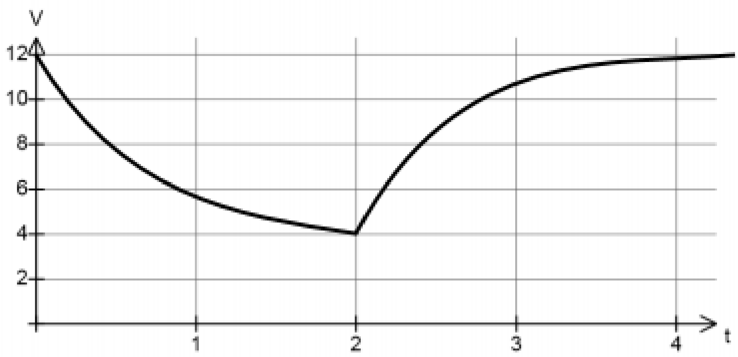
Part a) i) done well. Many students did not understand the word ‘package’ in the context of part ii). Mixed responses for part b) and whilst some were able to correctly identify the need to calculate the time constant very few realized this must be used together with the threshold of the gate.

a) i) NAND Gates ii) Packaged together in a quad or hex IC.
b) From left to right we have: Q, Trigger, V_I
c) Calculate time constant RC and compare this with threshold voltage for the NAND inputs.

Part 2 Section A

Question 14

a) Mostly calculated the time constant, Tc=RC = 5600 * 330 x 10-6 = 1.85 seconds correctly, a few students failed to convert units.
b) A significant number of students attempted to perform some calculation, but most realised that the correct answer was approximately 12V
c) Generally poorly answered. Most students showed the correct charging curves, however very few correctly identified and drew the graph for the transition between switch DOWN and UP.



Question 15

a) Generally answered correctly as logic HIGH
b) Most correctly answered that EN was active HIGH. Very few gave any explanation, and of those only one answered that it was related to the output state of the NAND gate and that the 10k resistor was to allow

the logic level to change. However, it is the markers opinion that the 10k resistor is not needed, and only confused students as to the EN pins function.

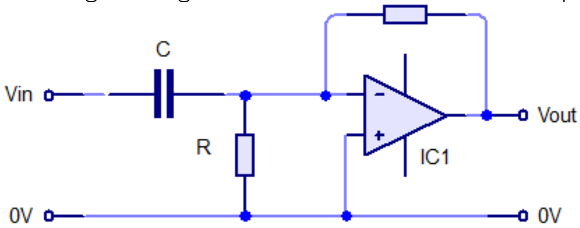
c) Most students could complete the remaining truth table entries. About half students correctly determined the EN column

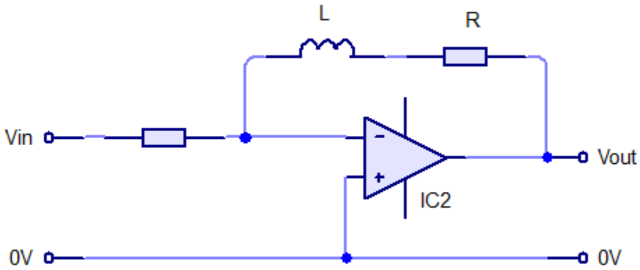
C	B	A		EN
0	0	0		1
0	0	1		1
0	1	0		1
0	1	1		1
1	0	0		1
1	0	1		1
1	1	0		0
1	1	1		0

d) Most students correctly determined that after 9 laps the counter would be on 1001, thus A & D would need to be connected. It was also accepted that after 9 laps (i.e counter on 10 = 1010) so B & D to be connected would be a valid interpretation to the question.

Question 16

a) Accepted any variation that was an active HP filter. Most students gave a reasonable response, with several omitting the negative feedback resistor in the amplifier. E.g.





b) Generally very poorly answered if at all. Accepted answers were:
   a. Inductors are larger/more expensive than capacitors
   b. LC filters have issues with resonance (~0 impedance at resonant frequency)

c) Generally very poorly answered if at all. Accepted answers were:
   a. Sharper roll off
   b. Better pass & stop characteristics
   c. Fewer components needed

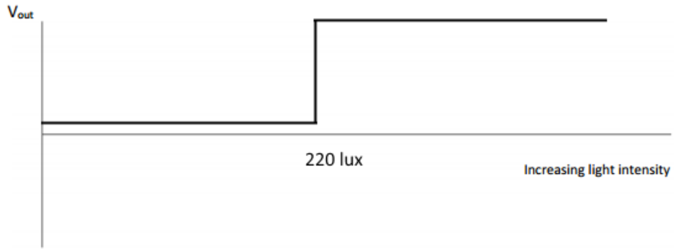
Question 17

a) Most students correctly identified that D1 would be lit. Many explanations were inaccurate or incorrectly correlated the current through the LDR as being the current through the LED. An acceptable answer identified that the LDR/R3 voltage divider would have a lower voltage in the dark, thus the non-inverting input would be below the inverting input voltage, thus the op-amp would saturate low, thus D1 would light

b) Most students correctly identified R3 as a Potentiometer (Variable Resistor was also accepted) with many also identifying that it was to calibrate/adjust the light level that the circuit would give YES/NO answer.

c) Most students could correctly identify that at 220 lux, the LDR would have a resistance of 2200Ω (±10% accepted). Very few could then use this, and the knowledge that at the threshold light level, the two voltage dividers needed the same ratio, i.e. $R1/R2 = R_{LDR}/R3$ to calculate that R3 needed to be 1000Ω (±10% accepted)

d) Most students correctly drew the graph, with some incorrectly having negative voltages or a gradual transition.



Question 18

a) Most students made reasonable answers for most parts, correctly identifying the roles as:
   i. Coupling/DC blocking capacitors
   ii. Voltage divider providing offset/bias for single supply amplifier
   iii. LP filter for power supply to pre-amp
   iv. IR receiver voltage divider circuit
   v. LP filter to remove noise/provide stability for LM386 amp

b) Most students correctly calculated the gain as -60

c) i) Most students identified the maximum voltage swing as 9V
   ii) Very few students calculated the RMS voltage from the maximum peak-peak voltage determined in i). Some students correctly used $P=V^2/R$ to determine the power in the speaker.

Question 19

a) most students correctly identified that there are two D-type flip flops in the one 4013 IC

b) i) Most students correctly identified R as being active HIGH, but only a few gave an acceptable reason that when circuit is powered on, R would go logic high momentarily until capacitor C2 charged up to allow R to go logic low – thus providing a switch-on-reset function. Also accepted that R is connected to ground through R5.
   ii) about half realised that connecting the power resets the flip flop. Only a few drew correct graph

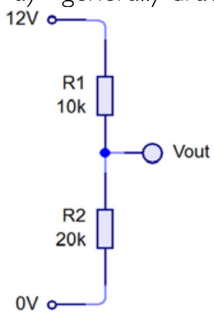
c) i) this question was generally poorly understood. Most gave an answer for only one of the pins. Accepted answer was R and CL go logic high, or flip flop resets and clock is triggered.
   ii) very few responses correctly graphed the voltage, or identified the purpose as being a switch debounce

d) i) most students correctly answered that the current output from the flip flop would not be enough to operate the relay correctly. A few students confused voltage with current.
   ii) most students correctly calculated either the maximum collector current as 44mA or the minimum required relay resistance as 120Ω. A few of those failed to state what this meant i.e. 44mA is less than the 100mA maximum current or 120Ωis less than the relays minimum resistance therefore is adequate.

Part 2 section B

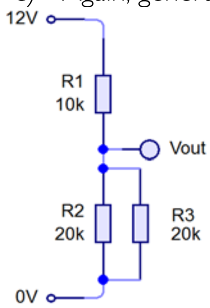
Question 20

a) generally drawn well, some failing to add the output voltage to their diagram.



b) i) Most correctly used the voltage divider formula to get 8V
ii) Most correctly used I=V/R = 8V/20k = 0.4mA

c) Again, generally drawn well with a few omitting the output voltage



i) most correctly calculated the parallel resistance as being 10k , thus the new output voltage as being 6V (most didn't calculate, just recognised the equal resistances) Several incorrectly stated that it would be half of the previous output voltage

ii) about half correctly calculated the current as being I = V/R = 6V/20k = 0.3mA. most common error was using combined resistance of 10k instead.

Question 21

a) Most students were generally able to correctly apply the dB=20log(Vout/Vin) formula to calculate gain as 69.5dB

b) Students had more trouble transposing to find Vout, part marks were given for using correct formula and values.

c) Most students correctly realised the total gain in dB is the sum of the individual gains in dB. A few calculated using their voltage from part b)

d) Most students correctly used $P=V^2/R$ to calculate the power as 72mW. Some students used incorrect voltages (i.e. their answer from b), or multiplied the 6V by 0.707 for an RMS conversion.

Question 22

a) Most students correctly used the resonance formula to get a frequency of 4381Hz. Some students failed to convert to Farads/Henrys

b) About half of responses realised that the combined reactance at resonance is 0, thus total impedance is just the resistive component = 7Ω

c) Most students correctly calculated both XL=13.8 Ω and XC=8.8 Ω, then found X=XL-XC

d) Most students were able to use Z= sqrt(R2+X2) = 8.6 Ω

Question 23

a) Most students correctly found the maximum current as 100mA from the table

b) i) most students correctly identified the forward voltage as 1.2V

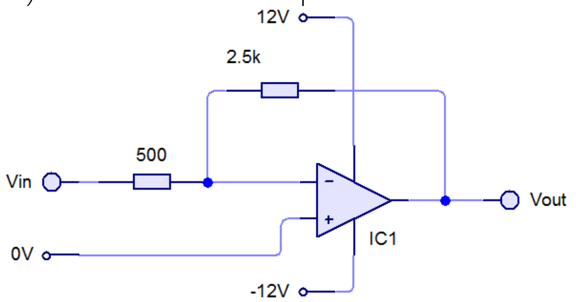
ii) Most students correctly determined the resistor voltage as being 9-1.2 = 7.8V. Several incorrectly answered 9V

c) most correctly used the R=V/I formula to determine resistance. Common errors were using 9V instead of 7.8V. Whilst the correct answer was 7.8/0.1 =78 Ω (choose 82 Ω E12 resistor) it was accepted to use 7.8/0.015 = 520 Ω (choose 560 Ω E12) if they chose to use 15mA as the LED forward current.

d) Most students correctly used $P=V^2/R$ = 742mW (or 109mW for 82 Ω) only part marks given for using P=VI (doesn't take into account the E12 being a different resistance)

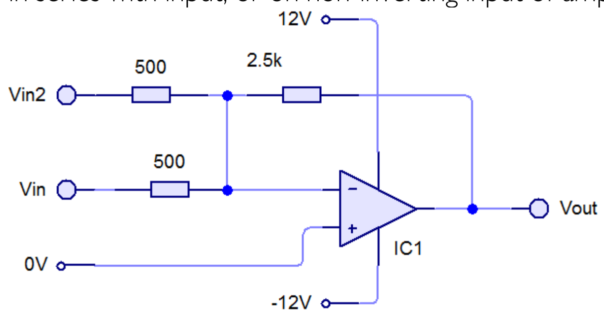
Question 24

a) Most students could produce some kind of diagram. A common error was drawing a non-inverting amplifier.



b) Most could calculate the gain as G=-2.5k/500 = -5. Common mistake was to not have negative gain value

c) About half students could correctly add a second input. Common error was to have the new 500 Ω resistor in series with input, or on non-inverting input of amplifier.



d) Most correctly calculated the output as being (0.2+0.5) x -5 = 3.5V peak

e) About 2/3rds correctly identified that the output would now exceed the 12V power supply, so would produce clipping on the output waveforms.

Question 25

Marks were given for (in no particular order):

- Reading the analogue value somehow
- Having the program loop
- Declaring variables/memory/symbols etc.
- Some use of a conditional statement (e.g. if adc_value>700 then…) that then changed an output
- Annotation/comments

No penalties were added for not using BASIC programming language.
Of those students that attempted the question (about half did not attempt) most had some use of conditional statements that changed an output. A few also declared variables etc. Only a couple used comments appropriately.

Example code:

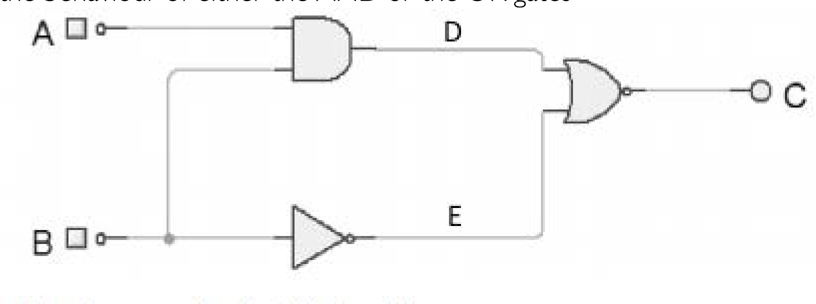
```
symbol LDR = pin3          'LDR voltage divider on pin 3
symbol light_level = b0 'where we store the ADC value
symbol headlights = 6   'headlights connected to pin 6

lightson:               'this subroutine has the headlights on
readadc light_level,LDR 'measure light level
if    light_level > 700 then goto lightsoff     'condition to turn lights
off
goto lightson           'loop back

lightsoff:              'this subroutine has the headlights off
readadc light_level,LDR 'measure light level
if    light_level < 340 then goto lightson      'condition to turn lights on
goto lightsoff          ' loop back
```

Question 26

a) Most students made a reasonable attempt at completing the truth table. Common mistakes were forgetting the behaviour of either the AND or the OR gates



A	B	D	E	C
0	0	0	1	0
0	1	0	0	1
1	0	0	1	0
1	1	1	0	0

b) Most students that answered a) provided a suitable statement "When A is low and B is high C is high" and Boolean expression $B \cdot \bar{A} = C$

c) Most students that answered a) made a reasonable attempt at the timing diagram. A common error was to omit the behaviour at the start of the graph