Government of **Western Australia**
School Curriculum and Standards Authority

ENGINEERING STUDIES

ATAR course examination 2018

Marking Key

Marking keys are an explicit statement about what the examining panel expect of candidates when they respond to particular examination items. They help ensure a consistent interpretation of the criteria that guide the awarding of marks.

2018/60316

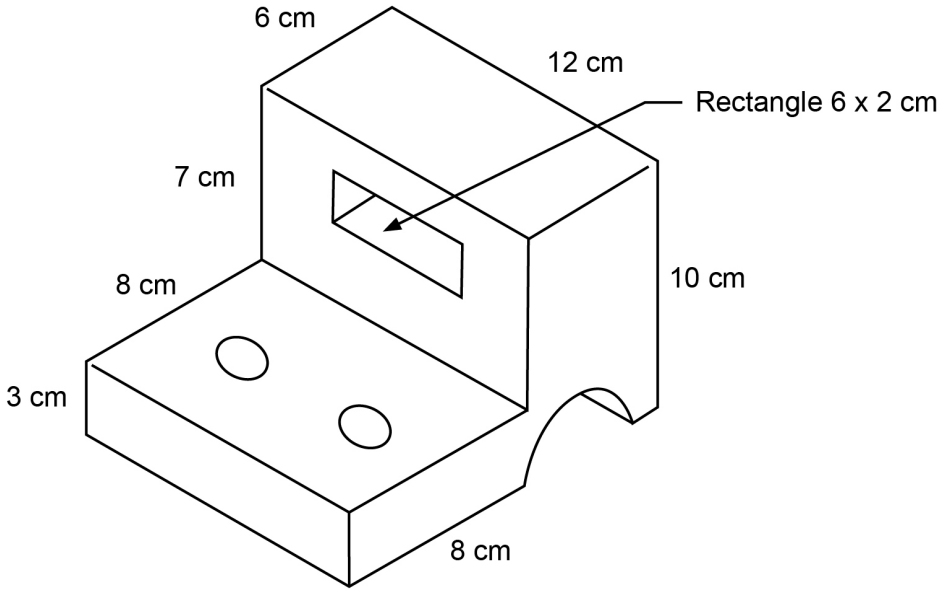
Section One: Core content **40% (68 Marks)**

Part A: Multiple-choice **10% (10 Marks)**

1	b
2	c
3	d
4	c
5	a
6	d
7	b
8	d
9	a
10	b

Part B: Extended response **30% (58 Marks)**

Question 11 **(15 marks)**



Description	Marks
correct view (three faces - pictorial)	1–3
Sub-total	**3**
Common to either pictorial or orthographic view	
external dimensions - all four correct	1–4
neatness overall	1
Sub-total	**5**
If uses pictorial view	
length, width and depth in proportion	1–2
correct position and proportion of the rectangular slot	1–2
correct position and proportion of holes	1–2
correct position and proportion of semi-circular opening	1
Sub-total	**7**
If uses orthographic view	
length and width full size	1–2
correct position and size of the rectangular slot	1–2
correct position and size of holes as hidden detail	1–2
correct position and size of semi-circular opening as hidden detail	1
Sub-total	**7**
Total	**15**

Question 12 **(12 marks)**

Complete the table below by naming the material you have studied this year that is **most** suitable for each of the given applications and give **one** reason why that material is fit for purpose.

Description	Marks
One mark per correct material and one mark for fitness of purpose	
names a suitable material for application	1
states reason material is fit for purpose	1
Subtotal	**2**
Total	**12**
Accept other relevant answers	

Application	Material	Fitness for purpose
frames and supports for solar panels	aluminium	non-corrosive, malleable, strong
tubing on the panels of solar hot water systems	copper	excellent conductor of heat, ductile
fibre optic cable	acrylic fibre	easy to bend, internally reflects light
lenses in protective glasses	polycarbonate	impact resistant, hard to crack
metal coating the surface of structural steel	zinc	stops iron from corroding by forming a (oxide) coating on the surface that does not flake off
3D printer filament	acrylonitrile butadiene (ABS)	relatively low melting point, hard setting

Question 13 **(17 marks)**

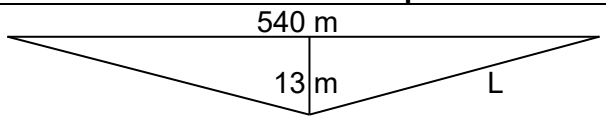
(a) Calculate the volume of metal in one of these cables. (3 marks)

Description	Marks
R = 0.0125 m	1
V = $\pi R^2 l$ = π x 0.0125^2 x 560	1
=0.2749 m^3	1
Total	**3**

(b) Determine the total mass of steel in all six cables. (3 marks)

Description	Marks
Density = 7850 kg m^3	1
Mass = density x volume = 7850 x 0.2749 x 6	1
= 12 948 kg	1
Total	**3**

(c) Calculate the length of the cable between the terminals when the carriage is centrally located across the gap. A diagram is required in your answer. (5 marks)

Description	Marks
	1
vertical drop in centre of cable = 73 – 60 = 13 m	1
$L^2 = (540/2)^2 + 13^2 = 73069$	1
L = 270.3 m	1
length of cable = 2 x 270.3 = 540.6 = 541 m	1
Total	**5**

(d) Explain, including a relevant calculation, why each counterweight has a mass of 10 tonnes. (3 marks)

Description	Marks
maximum downwards weight on cable when carriage is at the centre	1
weight of cable + weight of car = 12.9 + 7 = 19.9 tonne	1
downwards weight on each end needs to equal (or slightly exceed) half of this value therefore ten tonne each end will do this	1
Total	**3**
Accept other relevant answers	

(e) Calculate the energy expended per round trip in joules. (3 marks)

Description	Marks
Energy = Pt	
0.75E = Pt	1
E = (57 000 x 4.7 x 60 x 2)/0.75	1
= 4.286×10^7 J	1
Total	**3**

Question 14 **(14 marks)**

(a) The glass and aluminium greenhouse is being set onto a 75 mm thick concrete pad which is the exact size of the footprint of the greenhouse. Calculate the volume of concrete required in cubic metres. (3 marks)

Description	Marks
Area = (4.3 x 3.4) – (1.1 x 1.3 x 2)	1
= 11.76 m^2	1
Volume = 11.76 x 0.075 = 0.882 m^3	1
Total	**3**

(b) Give **two** reasons why steel is the preferred material for securing the greenhouse. (2 marks)

Description	Marks
Any **two** of: • strong • resists deformation • high tensile strength.	1–2
Total	**2**
Accept other relevant answers	

(c) Calculate the length of cable required for all three gable ends assuming that each cable needs an extra 100 mm in length to tie it to a peg on either side. (5 marks)

Description		Marks
Length of cable	= ground to top of wall + top of wall to apex = $[(1.9^2)+(0.5^2)]^{0.5}$ + $[(1.05^2)+(0.5^2)]^{0.5}$ =1.9647 + 1.1630m = 3.13 m	1–3
Total for one gable	= 2 x (1.9647 + 1.1630 + 0.1) = = 6.455 m	1
Total for all three gables	= 19.37 m (20 m)	1
	Total	**5**

(d) When the greenhouse is no longer required state how the following materials can be disposed of and what happens to them if they are recycled.

(i) Glass (2 marks)

Description	Marks
disposed of in general waste at a general rubbish tip	1
separated from waste then crushed, melted down and remoulded into bottles or jars	1
Total	**2**
Accept other relevant answers	

(ii) Concrete pad (2 marks)

Description	Marks
disposed of as clean landfill (not general rubbish tip)	1
crushed and recycled as road-base	1
Total	**2**
Accept other relevant answers	

Section Two: Specialised field—Mechanical **60% (110 Marks)**

Part A: Multiple-choice **10% (10 Marks)**

15	d
16	a
17	b
18	c
19	c
20	d
21	b
22	a
23	d
24	d

Part B: Extended answer **50% (100 Marks)**

Question 25 **(22 marks)**

(a) How far from the top of the vertical support is the stainless steel cable AD attached? (2 marks)

Description	Marks
$BD^2 = AD^2 – AB^2$ $= 2.40^2 – 2.00^2 = 1.76$	1
BD = 1.33 m	1
Total	**2**

(b) Calculate the second moment of area for this horizontal beam. (3 marks)

Description	Marks
$I_{xx} = bh^3/12$ $= 0.03 \times 0.07^3/12$	1–2
$= 8.575 \times 10^{-7}$ (answer must be in m^4 or mm^4)	1
Total	**3**

(c) Calculate the maximum bending moment of the beam at B before the sign is attached. (Assume the section AB remains horizontal and there is no significant bending in the vertical support.) (4 marks)

Description	Marks
$F_{UDL} = (148 \times 9.8/9) \times 7$ $= 1128$ N	1
$BM_{max} = F_{UDL}L/2$ $= 1128 \times 7/2$	1–2
$= 3948$ Nm	1
Total	**4**

(d) Calculate the maximum deflection of the beam at C before the sign is attached. (Assume the section AB remains horizontal and there is no significant bending in the vertical support.) (4 marks)

Description	Marks
$y_B = F_{UDL}L^3/8EI_{xx}$ $= (161.2 \times 7^3)/(8 \times 2 \times 10^{11} \times 8.575 \times 10^{-7})$	1–3
$= 0.0403$ m	1
Total	**4**

(e) Calculate the maximum deflection of the beam at C when the sign is attached. (Assume the section AB remains horizontal and there is no significant bending in the vertical support.) If you were unable to obtain a value for part (d), use 0.0500 m. (4 marks)

Description	Marks
$y_C = y_B + FL^3/3EI_{xx}$ $= 0.0403 + (60 \times 9.8 \times 5.5^3)/(3 \times 2 \times 10^{11} \times 8.575 \times 10^{-7})$	1–2
$= 0.0403 + 0.01941$	1
$= 0.0597$ m (0.0694)	1
Total	**4**

(f) Calculate the tension in the cable AD assuming the beam AC is horizontal. (5 marks)

Description	Marks
Moments about B Sum acm = sum cm	
$T_{cable} \sin 33.6° \times 2 = 148 \times 9.8 \times 2.5 + 60 \times 9.8 \times 5.5$	1–3
$T = (3626 + 3242)/1.107$	1
$= 6204$ N	1
Total	**5**

Question 26 **(15 marks)**

(a) Calculate the length of the ramp XP. (2 marks)

Description	Marks
XP = 28/sin38°	1
= 45.48 m	1
Total	**2**

(b) Calculate the time it takes for the roller-coaster to travel from X to P? (2 marks)

Description	Marks
t = s/v_{av} = 45.48/0.72	1
= 63.17 s	1
Total	**2**

(c) A person in the car when stationary at point P dropped a 150 g chocolate bar. How long would it take to hit the ground, assuming that it fell from the person's hand when it was 28.5 m above the ground? (Ignore any resistance.) (3 marks)

Description	Marks
s = $ut + 0.5at^2$ $28.5 = 0 + 0.5 \times 9.8t^2$	1
t = $\sqrt{\frac{28.5}{4.9}} = \sqrt{5.81}$	1
t = 2.41 s	1
Total	**3**

(d) Calculate the frictional force between the track and the car. (2 marks)

Description	Marks
F_f = 0.15mg = 0.15 x 1600 x 9.8	1
= 2352 N	1
Total	**2**

(e) Using this information calculate the force the motor must apply to the car to move it up this slope at a constant velocity. (4 marks)

Description	Marks
F = mgsin38° + F_f	1
= 1600 x 9.8 x sin38 + 2352 = 9654 + 2352	1–2
= 12 006 N	1
Total	**4**

(f) Determine the power rating of the motor used to achieve this task, if it is 80% efficient. If you were unable to obtain a value for part (e), use 11 000 N.

(2 marks)

Description	Marks
$0.8P = Fv_{av}$	1
P = 12 006 x 0.72/0.8 = 10 805 W (9900 W)	1
Total	**2**

Question 27 **(18 marks)**

(a) Indicate the direction of the car's acceleration in each of the following regions by circling the correct answer either up or down. (2 marks)

Description	Marks
(i) down	1
(ii) down	1
Total	**2**

(b) Explain the reasoning you used to choose your answer for (a)(ii) above. (2 marks)

Description	Marks
only acceleration on the car is due to a component of gravity	1
gravity is always vertically downwards	1
Total	**2**

(c) Calculate the speed of the roller-coaster car at point Q, assuming there is no energy losses between P and Q and PQ is a straight line. (3 marks)

Description	Marks
$0.5mv^2 = mgh$	1
$v = \sqrt{2gh}$ $= \sqrt{2\ x\ 9.8\ x\ 28}$	1
$= 23.43\ ms^{-1}$	1
Total	**3**

(d) Calculate the amount of energy 'lost' by the roller-coaster car between P and Q if its actual speed at Q is 20.6 ms^{-1}. (2 marks)

Description	Marks
$E_K = 0.5mv^2 - 0.5mu^2$ $= 0.5 \times 1600 \times [(23.43)^2 - (20.6)^2]$	1
$= 99\ 684\ J = 9.97 \times 10^4\ J$	1
Total	**2**

(e) With regard to this 'lost' energy:

(i) State the form of energy into which most of it is transformed. (1 mark)

Description	Marks
Heat	1
Total	**1**

(ii) State where this transformed energy immediately goes. (1 mark)

Description	Marks
into the rails/wheels of car	1
Total	**1**
Accept other relevant answer	

(f) Determine the proportion of the roller-coaster car's potential energy 'lost' by the time it reaches point Q? (4 marks)

Description	Marks
E_P at start = mgh = 1600 x 9.8 x 28 = 4.39 x 10^5 J	1
$0.5mv^2$= 0.5 x 1600 x 20.6^2 = 3.39 x 10^5	1
Proportion lost = (4.39 – 3.39)/4.39	1
= 0.228 or 22.8%	1
Total	**4**

(g) If this same proportion of energy is 'lost' as kinetic energy between Q and R, determine the maximum height of R above Q. If you were unable to obtain a value for part (f) use 25%. (3 marks)

Description	Marks
Energy at R = (1 - 0.228) x energy at Q	1
= 0.772 x 3.39 x 10^5 = 2.62 x 10^5 J (2.54 x 10^5 J)	1
At R mgh = 2.62 x 10^5	
h = 2.62 x 10^5/(1600 x 9.8) = 16.69 m (16.21 m)	1
Total	**3**

Question 28 **(17 marks)**

(a) Name the structural part of this crane that will be under compression. (1 mark)

Description	Marks
Jib	1
Total	**1**

(b) Determine the minimum radius of each of the steel lifting cables needed to lift a container filled with its maximum weight just before each cable undergoes plastic deformation. (6 marks)

Description	Marks
Force per cable = (27 300 x 9.8)/2	1
= 133 770 N	1
Yield stress = 250×10^6 Nm^{-2} (from data book) Stress = F/A	1
A = F/stress = $133\,770/(250 \times 10^6)$ = 5.35×10^{-4} m^2 per cable	1
A = πR^2 r^2 = $5.35 \times 10^{-4}/\pi$	1
r = 0.01305 m	1
Total	**6**

(c) Using 540 mm^2 as the cross sectional area for each lifting cable, determine the mass of the load that would need to be attached to cause these cables to break if an attempt was made to lift the container. (4 marks)

Description	Marks
UTS = 470×10^6 Nm^{-2} (from data book) UTS = F/A	1
F = UTS x A = $470 \times 10^6 \times 540 \times 10^{-6} \times 2$	1
= 507 600 N	1
Mass = F/g = 507 600/9.8 = 51 797 kg = 51 800 kg	1
Total	**4**

(d) State **two** situations that could arise in lifting a load requiring a factor of safety to be applied to the steel lifting cables. (2 marks)

Description	Marks
cross winds when lifting	1
any sudden movement of the load	1
Total	**2**
Accept other relevant answers	

(e) Calculate the increase in length of each steel lifting cable under this load at the point the container just started to rise from the wharf. (4 marks)

Description	Marks
$E = FL/A\Delta L$ $\Delta L = FL/EA$	1
$= (88\ 000 \times 40)/(2 \times 10^{11} \times \pi \times (4.15 \times 10^{-2})^2$	1–2
= 3.25 mm (0.00325m)	1
Total	**4**

Question 29 **(12 marks)**

(a) Calculate the downward force on the tow ball of the car when the trailer with boat and motor are attached to the car. The tow ball is the contact point between the boat trailer and the car. (4 marks)

Description	Marks
$\Sigma acm = \Sigma cm$ $rF_{motor} + rF_{hitch} = rF_{boat+trailer}$	1
$(1.2 \times 112 \times 9.8)+(2.5 \times F) = 0.50 \times 540 \times 9.8$	1–2
$F_{hitch} = 1328.88/2.5$ $= 531.5$ N	1
Total	**4**

(b) The power output of boat motors is almost exclusively measured using the unit of Horsepower (Hp). Given the power of this motor is 60 Hp, convert this into kilowatts given 1 Hp = 746 W. (1 mark)

Description	Marks
Power $= 60 \times 746/1000$ $= 44.76$ kW	1
Total	**1**

(c) Calculate the tension in the cable when it is parallel to the ramp. You are required to give the correct units in your answer. (4 marks)

Description	Marks
Total mass = 400 + 112 = 512 kg	1
$F = mg \sin\theta$ $= 512 \times 9.8 \times \sin 20$	1–2
= 1716 N (unit must be correct for this mark)	1
Total	**4**

(d) Suggest a suitable material for construction of the trailer. Give **two** reasons why this material was chosen. (3 marks)

Description	Marks
suitable materials either aluminium or galvanised iron	1
Any **two** of: • good corrosion resistance • strong • easy to work with	1–2
Total	**3**
Accept other relevant answers	

Question 30 **(16 marks)**

(a) Calculate the upward force required by each motor to enable the drone to hover at a constant height. Assume the drone does not lose any power during the flight and there are no external wind factors. (3 marks)

Description	Marks
$F = ma$ $= 0.734 \times 9.8 = 7.19$ N	1
$F_{up} = F_{down}$ $F \times 4 = 7.19$ $= 7.19/4$	1
$F_{each\ motor} = 1.80$ N	1
Total	**3**

(b) Using the maximum ascent, controlled descent and flight times, calculate the maximum height to which the drone can fly. Ignore any acceleration a deceleration effects. (4 marks)

Description	Marks
$t = 27 \times 60$ $= 1620$ s	1
$v = s/t$ $t = s/v$ $1620 = s/5 + s/3$	1
$1620 = (3s + 5s)/15$	1
$s = 3037$ m	1
Total	**4**

(c) Calculate the total time that the drone would take to ascend to 100 m, fly to the maximum range, return and perform a controlled descent to the ground, all at maximum speed. (Assume maximum speed is reached immediately on liftoff.) (6 marks)

Description	Marks
Ascent	
$t = s/v = 100/5$ $= 20$ seconds	1
Horizontal	
$s = 13\ 000 \times 2$ $= 26\ 000$ m	1
Convert velocity to ms^{-1} $v = 65/3.6$ $= 18.05\ ms^{-1}$	1
$t = s/v$ $= 26\ 000/18.05$ $= 1440$ s	1
Descent	
$t = s/v = 100/3 = 33.3$ s	1
Total time = 20 + 1440 + 33.3 = 1493 s or 24.9 min	1
Total	**6**

Question 30 (continued)

(d) The drone's camera is pointed vertically downward and takes square photographs. Calculate the surface area of land that it could photograph at a height of 100 m, given that a field of view of 78.8° means the angle of view to the vertical is 39.4°. (3 marks)

Description	Marks
Length of base = $100\tan\theta \times 2 = 164.3$ m	1–2
Area = $164.3^2 = 26\ 994$ m^2	1
Total	**3**

Section Two: Specialised field—Mechatronics **60% (110 Marks)**

Part A: Multiple-choice **10% (10 Marks)**

31	b
32	b
33	a
34	c
35	d
36	c
37	a
38	a
39	c
40	d

Part B: Extended answer **50% (100 Marks)**

Question 41 **(13 marks)**

(a) Calculate the voltage and the current capacity of this battery pack at the outputs AB. (2 marks)

Description	Marks
4.5 V + 4.5 V = 9 V	1
2 A	1
Total	**2**

(b) Determine the voltage and current capacity this cell would need to have so that this battery pack could supply 6 A at 4.5 V to the load. (2 marks)

Description	Marks
4.5 V	1
6 A – 2 A – 3 A = 1 A	1
Total	**2**

(c) Calculate the minimum Ah that the third cell connected between A and B must have to achieve this. (4 marks)

Description	Marks
Load	
1.2 A x 100 h =120 Ah	1
Duty Cycle	
120 Ah * 0.8 =96 Ah	1
Existing cells	
50 Ah + 30 Ah =80 Ah	1
Required cells	
= 96 Ah – 80 Ah = 16 Ah minimum	1
Total	**4**

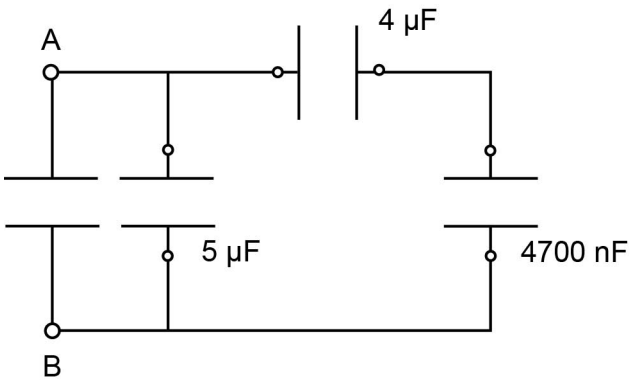
Question 41 (continued)

(d) Calculate the total capacitance across AB in the circuit below. (3 marks)

Description	Marks
4700 nF = 4.7μF	1
Cs = 1/($\frac{1}{4}$ + $\frac{1}{4.7}$) = 2.16 μF	1
$C_{a, b}$ = 2.16 μF + 5 μF = 7.16 μF	1
Total	**3**

(e) Calculate the value of the capacitor required to bring the total capacitance between A and B in the circuit above to 10 μF and correctly draw it into the circuit in part (d).
(2 marks)

Description	Marks
= 10–7 μF = 2.84 μF (in parallel)	1
drawing correct	1
Total	**2**



Question 42 **(15 marks)**

(a) Complete the table below identifying the components in the circuit. (6 marks)

Description		Marks
Diagram label	**Component**	
Vcc	DC voltage source/9 V battery	1
T1	NPN transistor	1
C1	(polarised) capacitor	1
L1	LED	1
R1	Resistor	1
S1	Switch	1
	Total	**6**

(b) Determine the initial value of the current i0 with switch S1 open. (1 mark)

Description	Marks
i0 = 0	1
Total	**1**

(c) Explain what happens to the current i1 and i2 over time when the switch S1 is closed. (2 marks)

Description	Marks
initially i1 is large and i2 is small as C1 charges	1
as C1 approaches full charge i2 approaches i0	1
Total	**2**
Accept other relevant answers	

(d) Explain what happens to the mode of T1 when the switch S1 is closed? (2 marks)

Description	Marks
starts in cut off	1
goes to forward active	1
Total	**2**
Accept other relevant answers	

(e) If C1 was reduced, what effect would this have on L1? State the reason for your answer. (2 marks)

Description	Marks
L1 would reach full brightness faster	1
because the capacitor C1 would reach full charge faster	1
Total	**2**
Accept other relevant answers	

(f) With reference to voltages V_E, V_B and V_C, how can we determine that T1 cannot go into saturation mode? (2 marks)

Description	Marks
for saturation $V_B > V_C$ in NPN transistor	1
V_B cannot be greater than V_C due to the voltage drop across R1 of Vcc	1
Total	**2**
Accept other relevant answers	

Question 43 **(19 marks)**

(a) Explain how you would measure the current flowing from the voltage source into the 1k2 Ω resistor. (3 marks)

Description	Marks
use an ammeter or multi-meter set to measure current	1
break the circuit and insert the meter in series	1
at points M and B (L & K are also acceptable)	1
Total	**3**
Note: if uses calculation of current only then award a maximum of 2 marks	

(b) Calculate the **maximum** possible total resistance of the circuit. (7 marks)

Description	Marks
$R_{BC, MAX}$ = 1200 Ω + 0.1 x 1200 Ω = 1320 Ω $R_{FH, MAX}$ = 2200 Ω + 0.1 x 2200 Ω = 2420 Ω	1–2
$R_{EG, MAX}$= 800 Ω + 0.05 x 800 Ω = 840 Ω $R_{GJ, MAX}$ = 3300 Ω + 0.05 x 3300 Ω = 3465 Ω	1–2
$R_{EJ, MAX} = R_{EG, MAX} + R_{GJ, MAX}$ = 840 Ω + 3465 Ω = 4305 Ω	1
$R_{DK, MAX} = 1/ ((1/ R_{FH, MAX}) + (1/ R_{EJ, MAX}))$ = 1/ ((1/2420 Ω) + (1/4305 Ω)) = 1549 Ω	1
$R_{T, MAX} = R_{BC, MAX} + R_{DK, MAX}$ = 1320 Ω + 1549 Ω = 2869 Ω (to the nearest Ohm)	1
Total	**7**
Not all working is required.	

(c) Calculate the **minimum** possible total resistance of the circuit. (7 mark)

Description	Marks
$R_{BC, MIN}$ = 1200 Ω - 0.1 x 1200 Ω = 1080 Ω $R_{FH, MIN}$ = 2200 Ω - 0.1 x 2200 Ω = 1980 Ω	1–2
$R_{EG, MIN}$ = 800 Ω - 0.05 x 800 Ω = 760 Ω $R_{GJ, MIN}$ = 3300 Ω - 0.05 x 3300 Ω = 3135 Ω	1–2
$R_{EJ, MIN} = R_{EG, MIN} + R_{GJ, MIN}$ = 760 Ω + 3135 Ω = 3895 Ω	1
$R_{DK, MIN} = 1/ ((1/ R_{FH, MIN}) + (1/ R_{EJ, MIN}))$ = 1/ ((1/1980 Ω) + (1/3895 Ω)) = 1313 Ω	1
$R_{T, MIN} = R_{BC, MIN} + R_{DK, MIN}$ = 1080 Ω + 1313 Ω = 2393 Ω (to the nearest Ohm)	1
Total	**7**
Not all working is required.	

(d) Calculate the **maximum** possible current flowing at i1. If you were unable to obtain an answer for part (c), use $R_{T\ MIN}$ = 2 600 Ω. (1 mark)

Description	Marks
Maximum current $i1_{MAX} = V_{CC}/R_{T,\ MIN}$ $i1_{MAX}$ = 12 V/2393 Ω $i1_{MAX}$ = 5.0 mA (4.6 mA)	1
Total	**1**

(e) Calculate the **maximum** possible power dissipated by the 1k2 Ω resistor. If you were unable to obtain an answer for part (d), use $i1_{MAX}$ = 4.6 mA. (1 mark)

Description	Marks
Maximum power $P_{BC,\ MAX} = (i1_{MAX}{}^2)R_{BC,\ min}$ $P_{BC,\ MAX} = (0.0050)^2$ x 1080 $P_{BC,\ MAX}$ = 27 mW (22.8 mW)	1
Total	**1**

Question 44 **(12 marks)**

(a) Name **one** advantage and **one** disadvantage of an open loop control system. (2 marks)

Description	Marks
Advantages	
Any of the following: • simple/economical • easy to maintain • stable	1
Disadvantages	
Any of the following: • inaccurate/output is not monitored • unreliable • cannot remove external disturbances	1
Total	**2**
Accept other relevant answers	

(b) Name **one** advantage and **one** disadvantage of a closed loop control system. (2 marks)

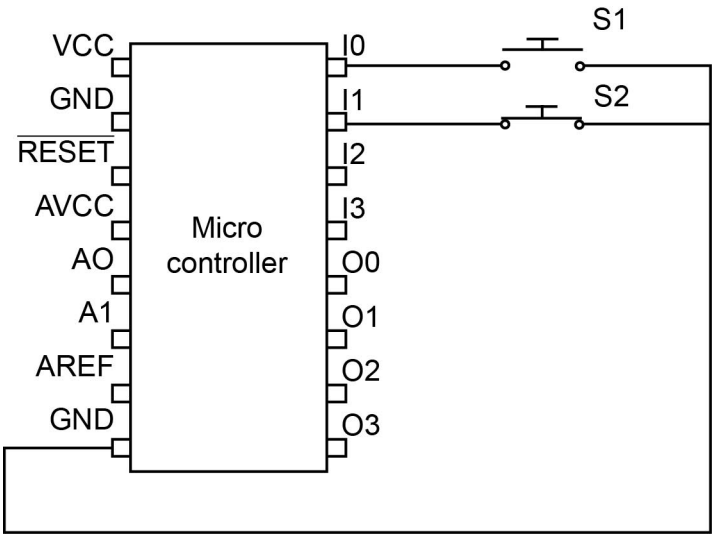
Description	Marks
Advantages	
Any of the following: • accurate • can remove external disturbances	1
Disadvantages	
Any of the following: • stability issues • complex/uneconomical • tuning/maintenance costs	1
Total	**2**
Accept other relevant answers	

(c) Complete the table below by identifying what should be at each of the labelled locations of the control system above. (8 marks)

	Description	Marks
A	desired speed (input)/set point	1
B	error	1
C	motor command	1
D	DC motor/plant	1
E	disturbances/power supply for motor	1
F	actual speed (output)	1
G	encoder/tachometer/feedback sensor	1
H	measured signal	1
	Total	**8**
Accept other relevant answers		

Question 45 **(27 marks)**

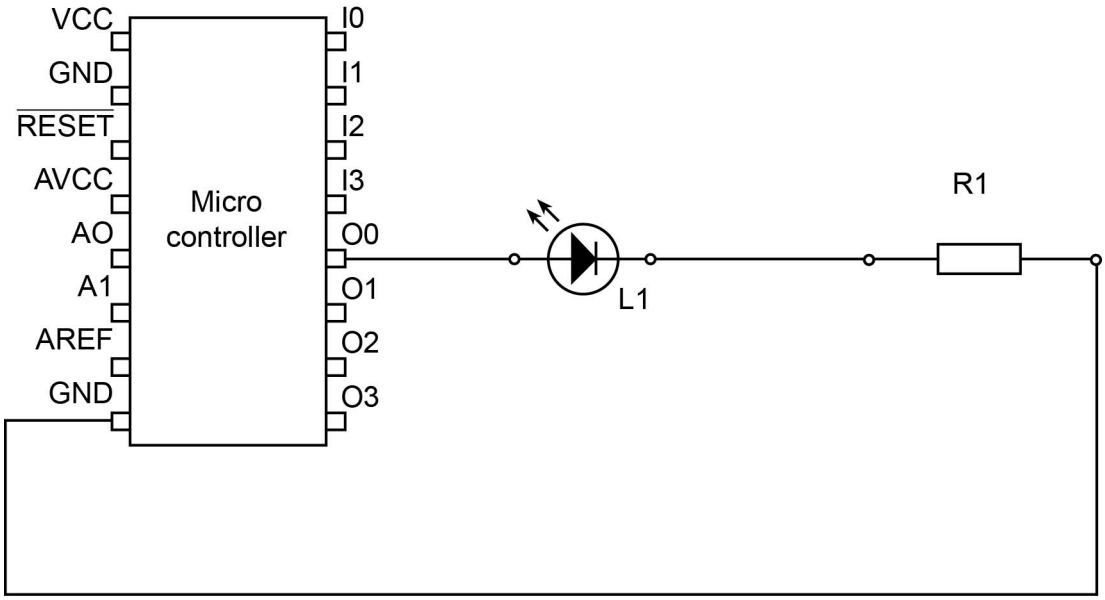
(a) The control system below will use a N/O switch S1 as an input that will later be programmed to turn on a motor. It will also have a N/C switch S2 connected as an input that will be programmed to be used for directional control of the motor. Draw the wiring diagram for this below. The input pins have internal pull up resistors that can be assumed to have been programmed to be on. (4 marks)



Description	Marks
switch 1 symbol correct and marked S1	1
switch 2 symbol correct and marked S2	1
S1 and S2 connected to input pins on one side	1
S1 and S2 connected to ground on other side (either GND)	1
Total	**4**

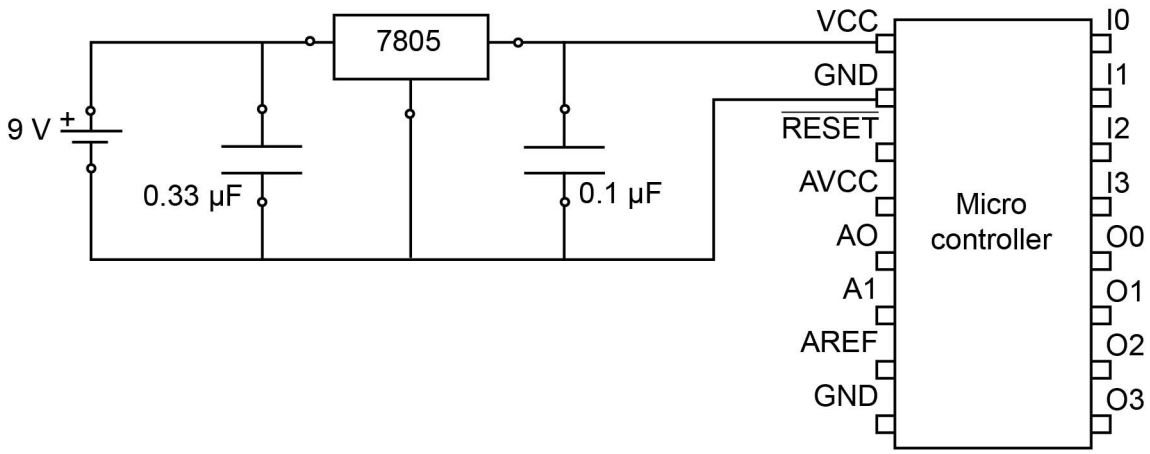
Question 45 (continued)

(b) The control system below will use an output to turn on a LED L1 with a resistor R1 in series. This will later be programmed to turn on when the motor is running. Draw the wiring diagram for this below. (4 marks)



Description	Marks
LED symbol correct and marked L1	1
circuit connected to output pin on one side	1
resistor in series with LED	1
circuit ends at GND (either GND)	1
Total	**4**

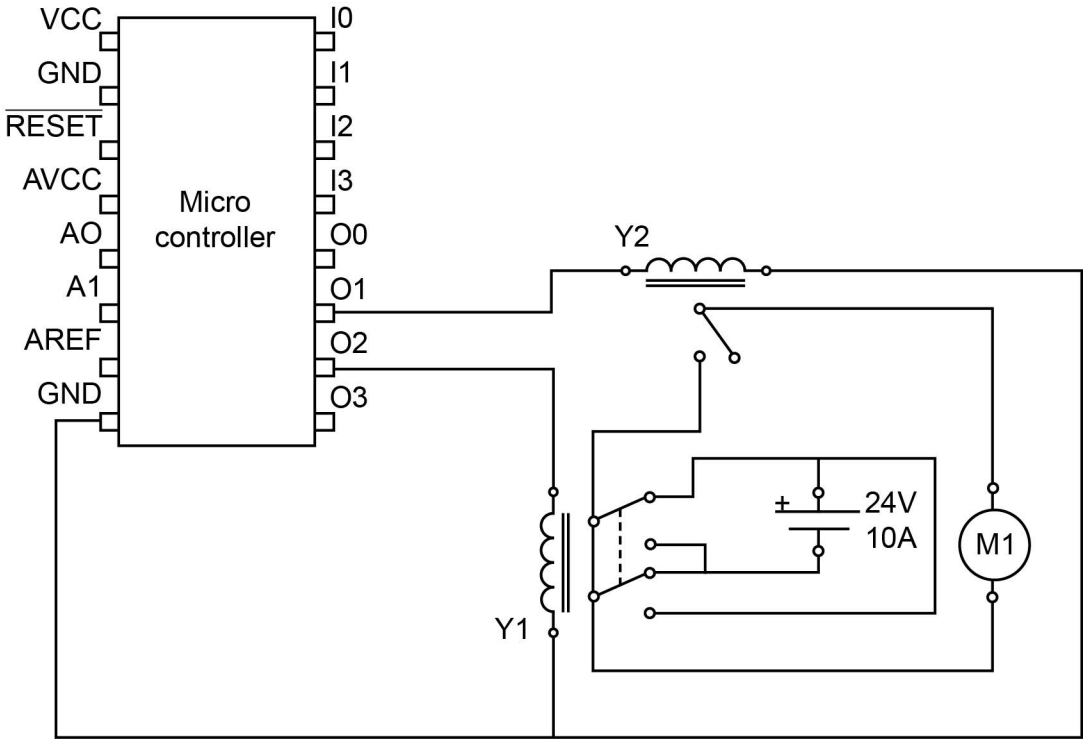
(c) Use the diagram below to draw a voltage regulator circuit to take a 9 V battery and provide the microcontroller the 5 V supply it requires. (7 marks)



Description	Marks
9 V DC symbol used	1
9 V supply connected correctly	1
capacitor 1 inserted and correct value	1
capacitor 2 inserted and correct value	1
7805 used and marked correctly	1
7805 IC connected correctly	1
correct pins connected to on microcontroller	1
Total	**7**

Question 45 (continued)

(d) The controller will use an output for a DPDT relay Y1, which will be used as a H bridge that will drive a motor M1 from a separate 10 A 24 V DC source. It will also use a SPDT relay Y2 triggered by an output to turn the motor power off and on. Draw this configuration, using the diagram below. (12 marks)



Description	Marks
DPDT relay component used and marked as Y1	1
output pin used for Y1 coil	1
one side of Y1 coil connected to ground	1
motor marked as M1	1
motor Connected correctly	1
correct supply symbol used	1
supply marked 24 V 10 A	1
supply connected correctly to DPDT	1
SPDT relay used and marked as Y2	1
output pin used for Y2 coil	1
one side of Y2 coil connected to ground	1
Y2 switch breaks power to M1	1
Total	**12**
errors carried forward full marks (misidentified pins only)	

Question 46 **(14 marks)**

(a) When the motor is rotating at 300 rpm, how fast is the winch rotating? (1 mark)

Description	Marks
v_w = 300/35 v_w = 8.57 rpm	1
Total	**1**

(b) If the motor is rotating at 300 rpm, how fast is the weight rising? If you did not get an answer for part (a), use 9 rpm. (3 marks)

Description	Marks
$v_1 = v_w \times 2 \times \pi \times r/60$ derive equation	1
Use v_w = 8.57 rpm from a r = d/2 = 0.1 m	1
v_1 = 5.38 m/min or = 0.0897 ms^{-1} (0.0942 ms^{-1})	1
Total	**3**
Accept other methods of deriving correct answer	

(c) At what rate does the motor need to spin for the weight to rise at 0.10 m s^{-1}? (3 marks)

Description	Marks
v_L = 0.1 m/s r = 0.1 m	
$v_L = v_w \times 2 \times \pi \times r/60$ v_w = 9.55 rpm	1–2
$v_m = v_w \times 35$ v_m = 334 rpm	1
Total	**3**
Accept other methods of deriving correct answer	

(d) For what period of time does the motor need to spin at 300 rpm for the weight to have risen 1.20 m? If you did not get an answer for part (b), use 95 mm s^{-1}. (3 marks)

Description	Marks
1.20/0.0897	1–2
t = 13.4 s (12.6 s)	1
Total	**3**

(e) If the velocity ratio is 1.01 and the distance moved by the load is 1.30 m, calculate the distance moved by the effort. (1 mark)

Description	Marks
d_e = 1.01 x 1.3 m d_e = 1.31 m	1
Total	**1**

Question 46 (continued)

(f) If the effective diameter of the output shaft of the gearbox is 20 mm does the winch or the gearbox have greater mechanical advantage in this system and why? (3 marks)

Description	Marks
gearbox	1
winch advantage is 20:200 or 1:10	1
gearbox advantage is 35:1	1
Total	**3**

ACKNOWLEDGEMENTS

Published by the School Curriculum and Standards Authority of Western Australia
303 Sevenoaks Street
CANNINGTON WA 6107