Principal Learning

Engineering

Unit **F559:** Instrumentation and Control Engineering

OCR Level 3 Principal Learning

Mark Scheme for January 2016

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

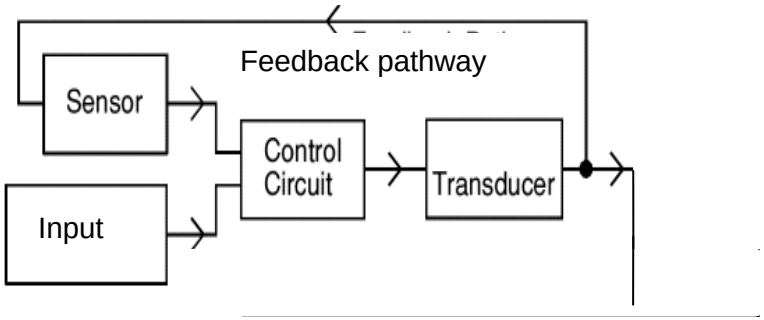
Mark schemes should be read in conjunction with the published question papers and the report on the examination.

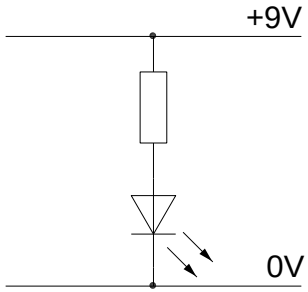
OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Question			Expected Answer	Mark	Rationale/Additional Guidance
A1				[3]	Award one mark for correctly positioned blocks, one mark for correctly positioned arrows and one mark for correct labels.
A2			Feed-forward	[1]	
A3			Proportional plus Integral	[1] [1]	
A4			cross-sectional area = force/ pressure = 10/5000 = 0.002 m^2	[1] [1]	Award one mark for cross-sectional area = force/ pressure or 10/5000. Award one mark for 0.002 m^2 or 0.002.
A5			Compressor. Non-return valve /shuttle valve	[1] [1]	
A6			A piezoelectric sensor is a device that uses the piezoelectric effect, to measure changes in pressure, acceleration, strain or force by converting them to an electrical charge.	[1] [1]	

Question			Expected Answer	Mark	Rationale/Additional Guidance
A7			Signal power may be reduced or lost The fields spread out around the wires Wires tend to act like an aerial Some of the power is radiated Resistance of the wire increases which causes the signal to become weaker	**[2]**	Accept any two correct adverse effects.
A8			Examples: Circuit Wizard, Maple Sim, Autodesk, Circuit Logix, Yenko, Crocodile Clips, Circuit Shop, VisSim, PowerEsim, Altium, Electric VLSI Design System, gpsim, SPICE, Oregano (software) Linux or BSD, KTechLab, gLogic, Logisim, Gnucap), Ngspice, Qucs), LTspice, SapWin, CPU Sim, Micro-Cap,	**[2]**	Accept any other correct simulation software packages. Award one mark for each correct package named.
A9			Weighbridge Load cell Monitoring of structural integrity	**[2]**	Accept any two correct responses. Accept any other correct responses.
A10			Allows designs to be changed easily. Less expensive when it comes to testing a design. Overcomes the need for specialised and expensive equipment. Always working in a safe environment. Programmes can be used at the designer's discretion.	**[2]**	Accept any two correct responses. Accept any other correct responses.
			Section A Total	**20**	

SECTION B

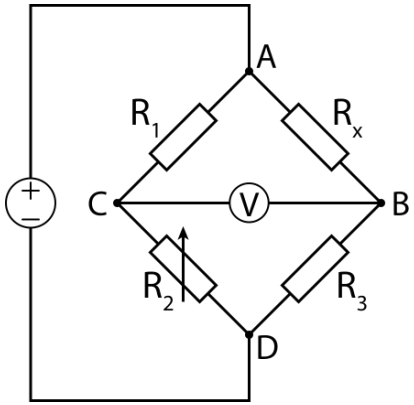
Question			Expected Answer	Mark	Rationale/Additional Guidance
1	(a)	(i)	Closed Loop	[1]	
1	(a)	(ii)		[3]	Award one mark for each correct label.
1	(b)		Overall gain G = A/(1 - βA) where A open loop gain Cross multiply: G(1 - βA) = A Open bracket: G - GβA = A Then GβA = G - A So β = (G - A)/GA β = (500 – 100)/(500 x 100) β = 400/50000 = 4/500 =1/125 or 0.008	[1] [1] [1] [1] [1] [1] [1]	
			Total	[10]	

Question			Expected Answer	Mark	Rationale/Additional Guidance
2	(a)		When a suitable voltage is applied to the terminals of an LED, energy is released in the form of photons. The photons emit light energy i.e. the LED lights up.	[1] [1]	Allow reference to LED lights up.
2	(b)	(i)		[3]	Award one mark for two correct symbols. Award one mark for a series circuit. Award one mark for a correctly labelled supply.
2	(b)	(ii)	To protect the LED from an excessive current.	[1] [1]	
2	(c)	(i)	$V_R = 6 - 2 = 4V$	[1]	

Question			Expected Answer	Mark	Rationale/Additional Guidance
2	(c)	(ii)	I = 0.01A R = V_R/I = 4/0.01 = 400R	 [1] [1]	 Award one mark for R = V_R/I or 4/0.01. Award one mark for 400R or 400 or 400Ω.
			Total	**[10]**	

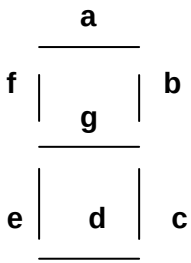
Question			Expected Answer	Mark	Rationale/Additional Guidance
3	(a)		Any two from: 1. Control valves 2. Actuators 3. Regulators 4. Production of compressed air	[1] [1]	
3	(b)	(i)	3/2 directional control valve.	[1]	
3	(b)	(ii)	Operator control Spring return	[1] [1]	

Question			Expected Answer	Mark	Rationale/Additional Guidance
3	(b)	(iii)	The pneumatic diagram in Fig. 3 shows how directional control valves can be switched. When operating control valve 1, control valve 2 will stop producing pressure output. When control valve 1 ceases operation and is restored to its original position, control valve 2 will resume its output. Therefore, at any given time, the pressure output of control valve 1 is the exact opposite of control valve 2. In logic terms this is a NOT gate.	[1] [1] [1] [1] [1]	Accept inverter.
			Total	[10]	

<table>
<tr><th colspan="3">Question</th><th>Expected Answer</th><th>Mark</th><th>Rationale/Additional Guidance</th></tr>
<tr><td>4</td><td>(a)</td><td></td><td>
<table>
<tr><th>Control System</th><th>Application</th></tr>
<tr><td>Servo</td><td>Power assisted steering</td></tr>
<tr><td>Temperature</td><td>Process vessel</td></tr>
</table>
</td><td>[3]</td><td>Award one mark for each correct application.</td></tr>
<tr><td>4</td><td>(b)</td><td>(i)</td><td>Multiplexer</td><td>[1]</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Analogue to digital converter</td><td>[1]</td><td></td></tr>
<tr><td>4</td><td>(c)</td><td></td><td> 
</td><td>[5]</td><td>Award one mark for supply.
Award one mark for voltmeter.
Award one mark for strain gauge R_x.
Award one mark for R_2.
Award one mark for R_1 and R_3.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>[10]</td><td></td></tr>
</table>

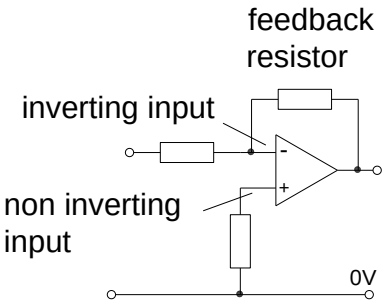
Question			Expected Answer	Mark	Rationale/Additional Guidance
5	(a)		A programmable logic controller, PLC or programmable controller is a **digital computer** used for automation of typically industrial electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are used in many industries and machines. PLCs are designed for **multiple analogue and digital inputs and output arrangements**, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a "hard" r**eal-time system** since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result. Whereas: A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller calculates an **error value as the difference between a measured process variable and a desired set point.** The controller attempts to minimize the error by adjusting the process through use of a manipulated variable. The PID controller algorithm involves **three separate constant parameters**, and is accordingly sometimes called three-term control: the proportional, the integral and derivative values, denoted P, I, and D.	**[1]** **[1]** **[1]** **[1]** **[1]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
			Simply put, these values can be interpreted in terms of time: P depends on the present error, I on the accumulation of past errors, and D is a prediction of future errors, based on current rate of change. **The weighted sum of these three actions is used to adjust the process** via a control element such as the position of a control valve, a damper, or the power supplied to a heating element.	**[1]**	
5	**(b)**		**Output**	**[4]**	Award one mark for each correct output.
		(i)	A		
		(ii)	C		
		(iii)	B		
		(iv)	D		
			Total	**[10]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
6	(a)	(i)	**Transducer**. An element that converts a change in some physical variable Into a related change in some other physical variable.	[1] [1]	
6	(a)	(ii)	**Actuator.** An element of a correction unit that provides the power to carry out the control action.	[1] [1]	
6	(a)	(iii)	**Regulator.** A device for controlling the rate of working of machinery or for controlling fluid flow, in particular a handle controlling the supply of steam to the cylinders of a steam engine.	[1] [1]	
6	(a)	(iv)	**Instrument display.** It is the choice of instruments used in a measurement display for a particular system.	[1] [1]	
6	(b)		**Seven segment display**  	[2]	Award one mark for diagram and one mark for correct position of at least one letter.
			Total	[10]	

Question			Expected Answer	Mark	Rationale/Additional Guidance
7	(a)		**Explain what is meant by the term embedded control system.** A computer that is built into another machine is known as an embedded control system.	 **[1]**	
7	(b)		**Name and explain the function of an embedded system that is used in a refrigerator.** An example is the embedded system in a refrigerator which will use a temperature sensor to measure the temperature inside the fridge and turn on a cooling unit if the temperature becomes too warm to keep food safely,	 **[1]** **[1]** **[1]**	Accept other correct responses.
7	(c)		**State three reasons why an embedded systems is used instead of a manual or mechanical control mechanism.** 1 Embedded systems can respond more quickly than mechanical devices or humans can. 2 Unlike a human embedded systems can work continuously without getting tired or making mistakes. 3 Embedded systems can have much more sophisticated features than equivalent manual systems.	 **[1]** **[1]** **[1]**	Accept other correct responses.

Question			Expected Answer	Mark	Rationale/Additional Guidance
7	(d)		**A modern car will incorporate many embedded systems to control various aspects of its use.** **State three situations where a car will use an embedded system.** Access Control/Alarm. A remote control can be used to lock and alarm a car when it is parked. Anti-Lock Braking (ABS). Computerised anti-lock braking systems allow cars to stop in shorter distances and be steered without skidding during breaking. Engine Control Unit. The engine control unit will determine the spark timing and amount of fuel to inject into the engine to obtain the best balance of performance, economy and environmental efficiency.	[1] [1] [1]	Accept other correct responses.
			Total	**[10]**	

Question			Expected Answer	Mark	Rationale/Additional Guidance
8	(a)		**Name two items of equipment that can be found as virtual instruments in simulation software.** Examples: Voltmeter Ammeter Ohmmeter Multi-meter Signal generator Oscilloscope Logic probe	**[2]**	Award one mark for each correct response up to a maximum of two marks. Accept any other correct response.
8	(b)	(i)		**[3]**	Award one mark for the inverting input negative (-) terminal. Award one mark for the non-inverting imput (+) terminal. Award one mark for the correct label of the feedback resistor.
8	(b)	(ii)	**Draw on the circuit diagram Fig. 5 the symbols of an instrument that will measure the input signal and the output signal**. 	**[2]**	Award one mark for each correctly positioned voltmeter.

Question			Expected Answer	Mark	Rationale/Additional Guidance
	(b)	(iii)	**State the voltage you would measure at the inverting input if the non- inverting input was recorded as – 5 volts.** – 5 volts	**[1]**	
	(b)	(iv)	**Calculate the closed loop gain if the feedback resistance is 200 kΩ and the input resistance is 10 kΩ.** Closed loop gain = R_f/R_i = 200/10 = 20	**[1]** **[1]**	Award one mark for Closed loop gain = R_f/R_i or 200/10. Award one mark for 20.
			Total	**[10]**	

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