

Principal Learning

Engineering

Unit **F559**: Instrumentation and Control Engineering

OCR Level 1 Principal Learning

Mark Scheme for January 2014

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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.

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Annotations in scoris

The following annotations are available:

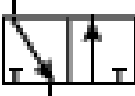
- ✓ = correct response
- ✗ = incorrect response
- ecf = error carried forward

BOD = Benefit of doubt

Highlighting is also available to highlight any particular points on the script.

SECTION A

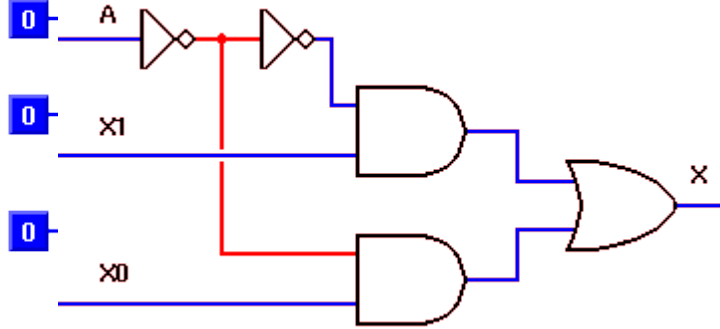
Question	Expected Answer	Mark	Rationale/Additional Guidance
1	<p>Name two input devices and two output devices that may be found in a control system.</p> <p>Input – Potentiometer/Thermistor/Light dependent resistor/ Potential divider circuits.</p> <p>Output – Monitor/Plotters/LED/Printer/Lamp/Speakers/ Bell/LCD Projector/ Buzzer.</p>	[4]	<p>Award one mark for each correct input device and one mark for each correct output device.</p> <p>Accept other correct responses.</p>
2	<p>Explain, using an example, what is meant by the term ‘open loop control.’</p> <p>An open loop system has three blocks, input, control and output linked together without a built in checking system. Examples: Domestic washing machine, electric toaster, gas ring, domestic oven, car cruise control, irrigation sprinkler, central heating, electric fire, car headlights</p>	[2]	<p>Allow marks for understanding shown.</p> <p>Award one mark for explanation and one mark for any correct example.</p>
3	<p>State two practical applications of a Light Dependant Resistor (LDR).</p> <p>Smoke detector Automatic lighting Counting Alarm systems. Night Light Control Oil Burner Flame Out Street Light Control Position Sensor Absence / Presence (beam breaker) Automatic Headlight Dimmer</p>	[2]	<p>Award one mark for each correct application.</p> <p>Accept other correct responses.</p>

Question	Expected Answer	Mark	Rationale/Additional Guidance
4	<p>Draw the symbol for a 3-port pneumatic valve in the space below.</p> 	[2]	Diagram - award one mark for showing the correct left half of the 3-port valve and one mark for showing the correct right half of the 3-port valve.
5	<p>Name three examples of instrumentation displays.</p> <p>Analogue and digital instruments eg. ammeter, voltmeter, ohmmeter Seven Segment display using LED's and LCD's Dot matrix Cathode Ray Oscilloscope.</p>	[3]	Award one mark for each correct name. Accept other correct responses.
6	<p>In a positive feedback amplifier the gain is 200. Calculate the overall gain when the feedback fraction 1/250.</p> $\begin{aligned} \text{Overall gain} &= A/(1 - \beta A) \\ &= 200/(1 - [1/250] \times 200) \\ &= 200/(1 - 0.8) \\ &= 200/0.2 \\ &= 1000. \end{aligned}$	[1] [1] [1]	Award one mark for the use of a correct formula. Award one mark for the use of a correct substitution. Award one mark for a correct answer. Award three marks for correct answer without working.

Question	Expected Answer	Mark	Rationale/Additional Guidance
7	<p>State two industrial applications of a Programmable Logic Controller (PLC).</p> <p>Traffic light control Furnace temp cascade control High speed counters Water supply tank control Automatic machining stations PCB rack positioning Chemical batch production Image processing inspection Automatic flow meter maintenance Food production High precision interrupt positioning</p>	[2]	<p>Award one mark for each correct application.</p> <p>Accept other correct responses.</p>
8	<p>Explain what is meant by the term 'digital signal' used in a electronic control system.</p> <p>A digital signal refers to an electrical signal that is converted into a pattern of bits. A digital signal has a discrete value at each sampling point. The precision of the signal is determined by how many samples are recorded per unit of time.</p> <p>The digital signal has two states ie. High/Low, On/Off or 1/0</p>	[1] [1]	<p>Allow marks for understanding shown.</p>
	Section Total	[20]	

Section B

Question		Expected Answer	Mark	Rationale/Additional Guidance
1	(a)	<p>Explain what is meant by the term ‘control’ in a control system.</p> <p>A control system is a device, or set of devices to manage, command, direct or regulate the behaviour of other devices or systems. Control can be either logical/sequential or feedback/linear.</p>	[1] [1]	Allow marks for understanding shown.
1	(b)	<p>Explain, in detail, the function of the:</p> <p>Tuner - a subsystem that receives radio broadcasts and converts them into audio-frequency signals which can be fed into an amplifier driving a loud speaker. Audio Amplifier – is an electronic amplifier that amplifies low-power audio signals (signals composed primarily of frequencies between 20 - 20 000 Hz, the human range of hearing) to a level suitable for driving loudspeakers and is the final stage in a typical audio playback chain. Loudspeaker – output device which is an electro-acoustic transducer that produces sound in response to an electrical audio signal input.</p>	[1] [1] [1] [1] [1]	Allow marks for understanding shown.
1	(c)	<p>Give two other practical applications for a control system other than a radio receiver.</p> <p>Temperature control/Logic control/Positional control/ PID control/Servomechanism control/ On-Off control.</p>	[1] [1]	Award one mark for each correct application. Accept other correct responses.
		Total	[10]	

Question	Expected Answer	Mark	Rationale/Additional Guidance
3 (a)	<p>Explain what is meant by the term ‘multiplexer’.</p> <p>The multiplexer is a switching device which enables each of several inputs to be sampled in turn and connected to a single analogue to digital converter.</p>	<p>[1]</p> <p>[1]</p>	<p>Allow marks for understanding shown.</p>
3 (b)	<p>Give two applications of a multiplexer used in domestic products .</p> <p>Most domestic appliances including cookers, washing machines, dishwashers, microwaves, refrigerators etc. Cell-phone systems Radio transmitter Computer networks Data Router Data Selector DVD player</p>	<p>[2]</p>	<p>Award one mark for each correct application.</p> <p>Accept other correct responses.</p>
3 (c)	<p>Describe, in detail, with the aid of a labelled diagram, the operation of a two input digital multiplexer.</p> 	<p>[6]</p>	<p>Diagram: Award one mark for showing A, X1 and X2. Award one mark for correct logic gates. Award one mark for showing output X.</p> <p>Award up to three marks for the description. Description must include reference to:</p> <ul style="list-style-type: none"> • Input A • Data inputs, X0 or X1 • Output x. <p>Accept any other correct type of diagram.</p>

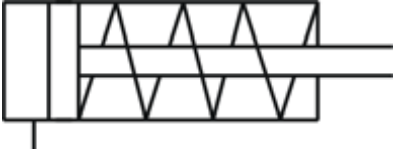
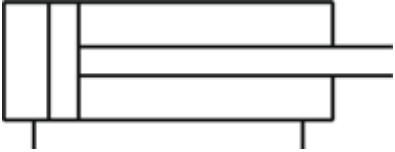
Question	Expected Answer	Mark	Rationale/Additional Guidance
	<p>The multiplexer circuit is typically used to combine two or more digital signals onto a single line, by placing them there at different times.</p> <p>Input A is the addressing input, which controls which of the two data inputs, X0 or X1, will be transmitted to the output.</p> <p>If the A input switches back and forth at a frequency more than double the frequency of either digital signal, both signals will be accurately reproduced, and can be separated again by a de-multiplexer circuit synchronized to the multiplexer.</p>		
	Total	[10]	

Question		Expected Answer	Mark	Rationale/Additional Guidance
4	(a)	<p>State two benefits of using light emitting diodes (LEDs) as compared to a signal lamp.</p> <p>Range of sizes and shapes available Longer lifetime than lamps/bulbs Low power consumption Available in different colours. Range of output intensities Available as bicolour or tricolour devices</p>	[2]	<p>Award one mark for each correct property.</p> <p>Accept other correct responses.</p>
4	(b)	<p>Give two practical applications of an LED.</p> <p>Bar-graph display Car lights Seven Segment display Domestic lighting Hexadecimal display TV screens Alphanumeric display.</p>	[2]	<p>Award one mark for each correct application.</p> <p>Accept other correct responses.</p>
4	(c)	<p>Describe in detail, how the circuit works.</p> <p>A Darlington pair ie. two transistor circuit, is sufficiently sensitive to respond to the small current passed by skin and it can be used to make a touch-switch as shown in the diagram.</p> <p>This is a two transistor circuit connected together so that the current amplified by the first transistor is amplified further by the second transistor. The overall current gain is equal to the two individual gains multiplied together.</p> <p>For this circuit which just lights an LED the two transistors can be any general purpose low power transistors.</p>	[6]	<p>Award up to six marks for the description.</p> <p>Description must include reference to:</p> <ul style="list-style-type: none"> • Touch-switch term • 100K resistor • 470R resistor • Two transistors • Current gain • LED.

Question	Expected Answer	Mark	Rationale/Additional Guidance
	<p>The 100K resistor protects the transistors if the contacts are linked with a piece of wire.</p> <p>TR1 can be a low power type, but normally TR2 will need to be high power. The maximum collector current $I_{c(max)}$ for the pair is the same as $I_{c(max)}$ for TR2.</p>		
	Total	[10]	

Question		Expected Answer	Mark	Rationale/Additional Guidance
5	(a)	<p>Explain what is meant by the term ‘actuator’ used in a control system.</p> <p>An actuator is a type of device for moving or controlling a mechanism or system. It is operated by a source of energy, usually in the form of an electric current, hydraulic fluid pressure or pneumatic pressure, and converts that energy into some kind of motion.</p>	[1] [1]	Allow marks for understanding shown.
5	(b)	<p>Give two practical applications of an actuator.</p> <p>Actuators typically are used in manufacturing or industrial applications and might be used in devices such as motors, pumps, switches and valves.</p>	[1] [1]	Award one mark for each correct application. Accept other correct responses.
5	(c)	<p>Describe what is meant by the following types of motion.</p> <p>Linear motion is motion along a straight line, using only one spatial dimension. The linear motion can be of two types: uniform linear motion, with constant velocity or zero acceleration; non uniform linear motion, with variable velocity or non-zero acceleration.</p> <p>Rotary motion is spinning or turning motion that takes place around an axis, without a change in linear position ie. motion created in a circular pattern.</p> <p>Oscillating motion - motion that moves forwards or backwards in an arc or circle repeatedly.</p>	[2] [2] [2]	Allow marks for understanding shown.
		Total	[10]	

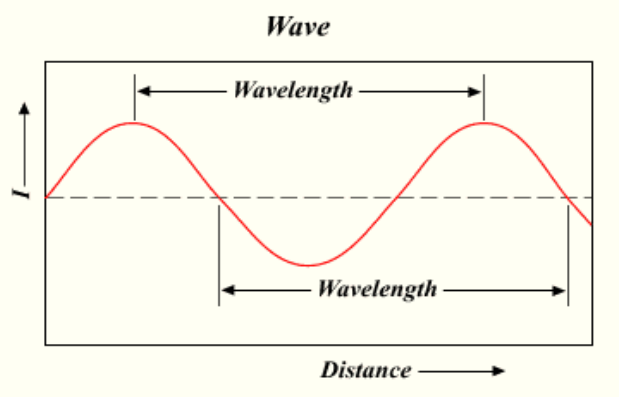
Question		Expected Answer	Mark	Rationale/Additional Guidance
6	(a)	<p>Explain how a solenoid valve operates.</p> <p>A solenoid valve is an electromechanical device used for controlling liquid or gas flow. The valve is controlled by an electric current through a coil i.e. the solenoid: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. A solenoid valve has two main parts: the solenoid and the valve. The solenoid converts electrical energy into mechanical energy which, in turn, opens or closes the valve mechanically.</p> <p>Solenoid valves may use metal seals or rubber seals, and may also have electrical interfaces to allow for easy control. A spring may be used to hold the valve opened (normally open) or closed (normally closed) while the valve is not activated</p>	[2]	Allow marks for understanding shown.
6	(b)	<p>Give two practical applications of a solenoid valve.</p> <p>Laundry and dry-cleaning equipment/ Industrial washing equipment/ Autoclaves/sterilizers/ Compressors and vacuum pumps/ Plastic moulding machinery/ Steam boilers/ Food processing machinery/ Sprinklers and fire fighting systems/ Coffee machines/ Boilers.</p>	[2]	<p>Award one mark for each correct application. Accept other correct responses.</p> <p>Note: Solenoid valves are used to control air, steam, oil, and gas.</p>
6	(c)	<p>Describe, with the aid of labelled diagrams, the construction and action of a single acting pneumatic cylinder and a double acting pneumatic cylinder. Include a use of each cylinder in your answer.</p>		Allow marks for understanding shown.

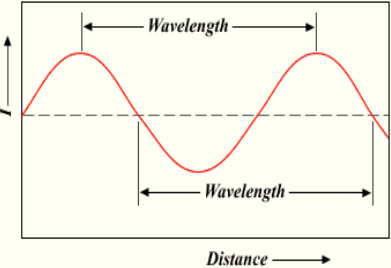
Question	Expected Answer	Mark	Rationale/Additional Guidance
	<p>Single acting pneumatic cylinder</p>  <p>Construction – Cylinder with vent. Piston with spring. Action - Single-acting cylinders use the pressure imparted by compressed air to create a driving force in one direction (usually out), and a spring to return to the "home" position. Use – Operating a micro switch, clamping work to a machine table, operating a valve, opening a sliding door, removing components from a conveyor belt</p> <p>Double acting cylinder</p>  <p>Construction – cylinder with two vents + Piston. Action – Double-acting cylinders use the force of air to move in both extend and retract strokes. They have two ports to allow air in, one for outstroke and one for in-stroke. Stroke length for this design is not limited. Use – Raising and lowering doors in a furnace remote control of double pressure operated 5-port valve, remote pilot valve control of degreasing equipment, operation of vice with piston speed control, operating a greenhouse window, air bleed circuit, operation of a train door.</p>	<p>[1]</p> <p>[1]</p> <p>[1]</p> <p>[1]</p> <p>[1]</p> <p>[1]</p>	
	Total	[10]	

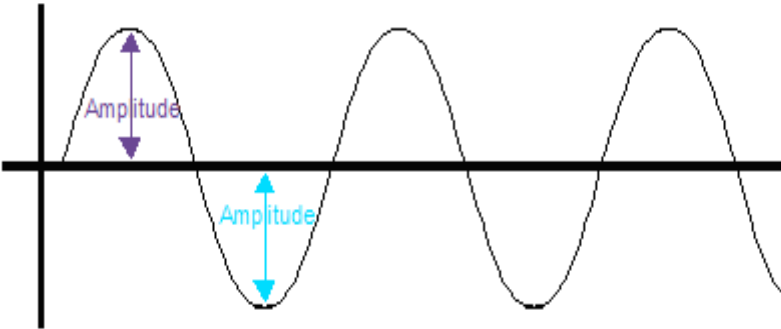
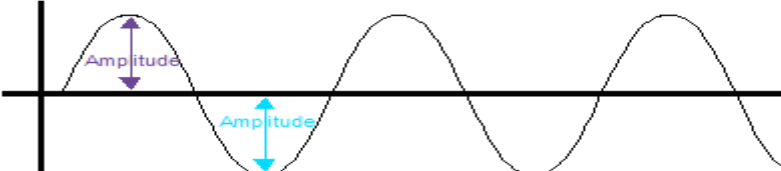
Question		Expected Answer	Mark	Rationale/Additional Guidance
7	(a)	<p>Describe how a monitoring control system could deny an intruder access to an engineering workshop.</p> <p>When an intruder is detected by the system they are denied access because sensors are activated.</p> <p>Sensors - flashing lights, sounding of sirens, links to the police, lowering of guards.</p> <p>This type of action denies access.</p>	<p>[1]</p> <p>[1]</p>	<p>Allow marks for understanding shown.</p>
7	(b)	<p>Explain in detail, the function of an embedded control system used in a monitoring system.</p> <p>An embedded system is a <u>computer system</u> designed to perform one or a few dedicated functions often with <u>real-time computing</u> constraints.</p> <p>It is embedded as part of a complete device often including hardware and mechanical parts.</p> <p>Embedded systems are controlled by one or more main processing cores that are typically either <u>microcontrollers</u> or <u>digital signal processors</u>.</p> <p>The key characteristic, however, is being dedicated to handle a particular task, which may require very powerful processors.</p> <p>Since the embedded system is dedicated to specific tasks, design engineers can optimize it to reduce the size and cost of the product and increase the reliability and performance.</p> <p>Some embedded systems are mass-produced, benefiting from <u>economies of scale</u>.</p> <p>Complexity varies from low, with a single <u>microcontroller</u> chip, to very high with multiple units, peripherals and networks mounted inside a large <u>chassis</u> or enclosure.</p>	<p>[6]</p>	<p>Description must include reference to</p> <ul style="list-style-type: none"> • embedded systems • dedicated functions • real time computing • function • purpose • reliability and performance. <p>Award one mark for each correct point made up to a maximum of six marks.</p>

Question		Expected Answer	Mark	Rationale/Additional Guidance
7	(c)	<p>State two other applications that use a monitoring system.</p> <p>Detection of an outbreak of fire Alert to an increase in temperature in a refrigeration plant. Detection of escape of radiation Alert to release of chemicals into the atmosphere. Wireless remote monitoring system on a landfill flare station Goods on a conveyor belt</p>	[2]	<p>Award one mark for each correct application.</p> <p>Accept other correct responses.</p>
		Total	[10]	

Question		Expected Answer	Mark	Rationale/Additional Guidance
8	(a)	<p>Give two reasons for using simulation software to construct a circuit.</p> <p>Circuit need not be physically built Simulation can be saved Less expensive – no need to purchase components Modifications are easier with a simulated circuit. Visual feedback from all points in the circuit.</p>	<p>[1]</p> <p>[1]</p>	<p>Accept any two correct reasons. Accept other correct reasons.</p>
8	(b)	<p>Give two reasons for using a virtual signal generator to test a simulated circuit.</p> <p>A signal generator is an electronic test instrument that delivers a sinusoidal output at an accurately calibrated frequency for use in testing circuits. Tests can determine whether or not the circuit is fit for purpose. Circuit can be modified and retested quicker than a real circuit. Helps circuit designers test ideas before actually building real circuits, saving much time and money. Relatively simple to use.</p>	[2]	<p>Accept any two correct reasons. Accept other correct reasons.</p>
8	(c)	<p>(i) Name the wave forms Y and Z.</p> <p>Waveform Y – sine wave Waveform Z - triangular wave.</p>	[2]	

Question	Expected Answer	Mark	Rationale/Additional Guidance
8 (c) (ii)	<p>Describe, with the aid of a diagram, what happens to the output signal when the frequency multiplier slide control is adjusted.</p> <p>The frequency of a wave is the number of waves produced by a source each second. It is also the number of waves that pass a certain point each second.</p> <p>The wavelength of a wave is the distance between a point on one wave and the same point on the next wave.</p> <p>An example of adjusting the frequency multiplier slide control is shown. In this case the wavelength decreases.</p> <p>Original waveform</p> 	[2]	

Question	Expected Answer	Mark	Rationale/Additional Guidance	
	<p>Modified waveform</p> <p style="text-align: center;"><i>Wave</i></p>  <p>If the slider had been moved in the opposite direction, the wavelength would have increased.</p>			
8	(c) (iii)	<p>Describe, with the aid of a diagram, what happens to the output signal when the amplitude slide control is adjusted.</p> <p>The amplitude of a wave is its maximum disturbance from its undisturbed position. The amplitude is not the distance between the top and bottom of a wave. An example of adjusting the amplitude slide control is shown. In this case the amplitude decreases.</p>	[2]	

Question	Expected Answer	Mark	Rationale/Additional Guidance
	<p data-bbox="367 272 611 304">Original waveform</p>  <p data-bbox="367 719 618 751">Modified waveform</p>  <p data-bbox="367 1050 1120 1118">If the slider had been moved in the opposite direction, the amplitude would have increased.</p>		
	Total	[10]	

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