

Principal Learning

Engineering

OCR Level 3 Principal Learning in Engineering **F559**

Unit **F559**: Instrumentation and Control Engineering

Mark Scheme for June 2011

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Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

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Section A

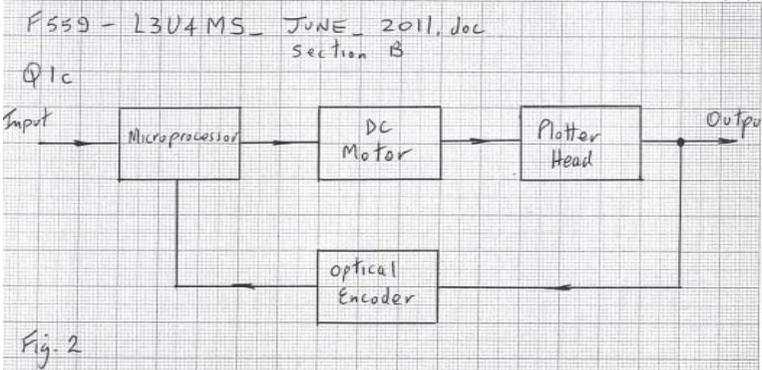
Question	Expected Answer	Mark	Rationale/Additional Guidance
1	<p>State which element is the input and which element is the output.</p> <p>Input – Temperature</p> <p>Output – Electromotive force (emf)</p>	[2]	
2	<p>Draw a labelled block diagram of a closed loop system.</p> <p>Accept any correct response. An example is given.</p> <pre> → Input → Control → Output → ↑ ↓ Feedback </pre> <p>Correctly positioned blocks Correctly positioned arrows Correct labels</p>	[1] [1] [1]	<p>Allow feed back arrow between input and control</p> <p>Accept 'process' instead of control</p>
3	<p>Explain what is meant by the term 'signal processor'.</p> <p>A signal processor is used for the element that takes the output from the sensor and converts it into a form which is suitable for data presentation</p>	[1] [1] [1]	Allow marks for understanding shown
4	<p>Name two passive transducers.</p> <p>Examples include: Light dependent resistor Strain gauge Thermistor</p>	[2]	Accept any other correct responses

Question	Expected Answer	Mark	Rationale/Additional Guidance
5	<p>Explain the operation of a 'bimetallic strip'.</p> <p>Two different metal strips are bonded together.</p> <p>When heated, because the metals have different rates of expansion, (coefficient of linear expansion).</p> <p>The strip bends into a curve</p>	<p>[1]</p> <p>[1]</p> <p>[1]</p>	<p>Allow use of an example to confirm understanding of the strip bends into a curve.</p> <p>For example; This movement can then be used to open or close an electrical switch.</p>
6	<p>Give three benefits of using simulation software.</p> <p>Examples include:</p> <ul style="list-style-type: none"> • Reduction of travel time to real life site/situation • Expenses are reduced ie travel, energy. • Safer than being exposed to dangerous situations • See more detail on the simulation compared to real life situations eg: 3D views • Allows access to situations which would otherwise be difficult to experience eg destructive testing • Reduces the need for specialised and expensive equipment • Any size of system can be produced as a simulation • Users can access simulation software packages at any time • No component cost • Values of components can be easily changed • Ranges of designs can be compared • Simulation times can be adjusted 	<p>[3]</p>	<p>Accept examples originating from specific types of software</p> <p>Award one mark for each correct example given</p>
7	<p>A data presentation element has an input which results in a pointer moving across a scale. Name this type of display.</p> <p>Analogue or indicator</p>	<p>[1]</p>	

Question	Expected Answer	Mark	Rationale/Additional Guidance
8	<p>A pneumatic cylinder has a piston of cross-sectional area 0.05 m^2. Calculate the working pressure applied to the cylinder when the force exerted by the piston is 50 kN.</p> <p>Pressure = force/cross-sectional area = $50/0.05$ = 1000 kN m^{-2}</p>	[1] [1] [1]	Award three marks for correct answer with or without units or working
	Section Total	[20]	

Section B

Question		Expected Answer	Mark	Rationale/Additional Guidance
1	(a)	<p>Give the meaning of the term 'servo control system'.</p> <p>Any machine or piece of equipment that has moving parts could contain one or more servo control systems.</p> <p>A servo control system could:</p> <ul style="list-style-type: none"> • maintain the speed of a motor within certain limits even when the load on the output of the motor might vary, called regulation • vary the speed of a motor and load according to an externally set of programmed values, called set point tracking • control linear or reciprocating movement 	<p>[1]</p> <p>[1]</p>	Allow mark for understanding
	(b)	<p>State three practical applications that use a servo control system.</p> <p>Examples include: Factory production lines Electric traction units Computer disc drives Music and games systems</p>	[3]	Award one mark for each correct application

Question	Expected Answer	Mark	Rationale/Additional Guidance
(c)	<p>Describe, in detail, with the aid of a labelled block diagram, how a direct current motor can be used in a positional control system. An example is given.</p>  <p>Correct diagram and labels</p> <p>The direct current servo system is made up of an electric motor with an output shaft that has an inertial load unit on it, and friction in the bearings of the motor and the load. There will be an electric drive circuit where an input voltage is transformed by the motor into a torque in the motor output shaft.</p> <p>A dc motor is used as the actuator to drive the belt on the plotter head. The feedback signal is provided by a microprocessor optical encoder.</p> <p>The feedback from the encoder gives the actual position of the plotter head. This is compared by the comparator with the signal from the computer indicating the required position.</p> <p>The error signal is then used to drive the motor and moves the plotter head to reduce the error to zero. As the input signal changes, so the error changes and the head has to move to maintain zero error.</p>	[1]	<p>Description must include references to</p> <ul style="list-style-type: none"> • a dc motor • the positional control system • feedback • error correction
		[4]	

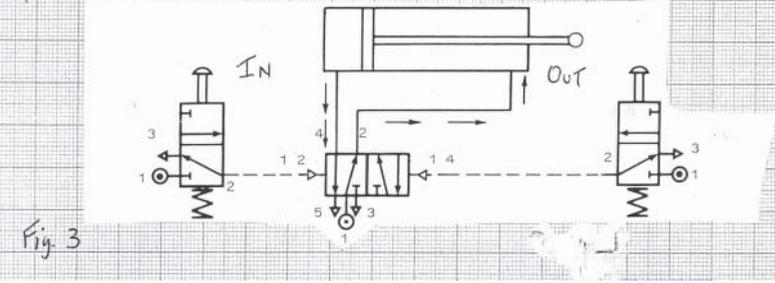
Question		Expected Answer	Mark	Rationale/Additional Guidance
2	(a)	<p>Give the meaning of the term 'gain' in an operational amplifier'.</p> <p>The role of an amplifier is to produce an output which is different to the input.</p> <p>Amplification of one or more of, input voltage, current or power.</p>	[1]	Allow use of formula for gain
			[1]	
	(b)	<p>Give three practical applications of an operational amplifier.</p> <p>Examples include:</p> <ul style="list-style-type: none"> • Audio frequency amplifier • Radio frequency amplifier • Power amplifier • Inverting and non-inverting amplifier • Summing amplifier – mixers • Comparator – alarm circuits • Integrator – ramp generator 	[3]	Accept any three correct applications

Question		Expected Answer	Mark	Rationale/Additional Guidance
	(c)	<p>In a positive feedback amplifier the gain is 200. Calculate, correct to one decimal place, the overall gain when the feedback fraction is</p> <p>(i) 0.002.</p> $\begin{aligned} \text{Overall gain} &= A/(1 - \beta A) \\ &= 200/(1 - 0.002 \times 200) \\ &= 200/0.6 \\ &= 333.3 \end{aligned}$	<p>[1]</p> <p>[1]</p>	Award two marks for correct answer with or without or working
		<p>(ii) - 0.002.</p> $\begin{aligned} \text{Overall gain} &= A/(1 - \beta A) \\ &= 200/(1 - \{-0.002 \times 200\}) \\ &= 200/1.4 \\ &= 142.9 \end{aligned}$	<p>[1]</p> <p>[1]</p> <p>[1]</p>	Award three marks for correct answer with or without working
		Total	[10]	

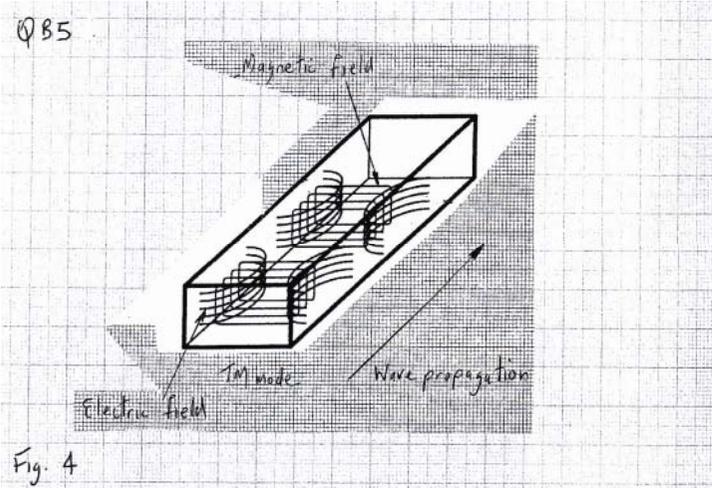
Question		Expected Answer	Mark	Rationale/Additional Guidance
3	(a)	<p>Name the components labelled A and B in the circuit</p> <p>Component A – Light dependent resistor (LDR) Component B – Operational Amplifier</p>	<p>[1] [1]</p>	
	(b)	<p>State three practical applications that uses an automatic lighting circuit</p> <p>Examples include: Part of a security system in a factory Safety measure in road-works Automatic kerb lighting Home safety – illuminated pathways Camera flash system Any situation when it goes dark a light will come on automatically</p>	[3]	Accept any three correct applications

Question	Expected Answer	Mark	Rationale/Additional Guidance
(c)	<p>Explain in detail, the principle of operation of the automatic lighting circuit</p> <p>Resistor R_1 is part of a potential divider. The resistors divide the input voltage applied across it into a number of equal parts so that the output voltage it supplies is a certain fraction of the input voltage</p> <p>The variable resistor V_R or potentiometer sets the light levels at which the light comes on</p> <p>The light dependent resistor (A) detects differing light levels/resistance levels and determines switching levels</p> <p>The operational amplifier (B) calculates and amplifies the difference between pins 2 and 3 for the output and corrects the analogue input to the digital input</p> <p>Finally the signal lamp (L) lights up and act as an output device</p>	<p>[1]</p> <p>[1]</p> <p>[1]</p> <p>[1]</p> <p>[1]</p>	<p>Explanation must include references to the role of</p> <ul style="list-style-type: none"> • the potential divider • the variable resistor • the LDR • operational amplifier • signal lamp
	Total	[10]	

Question		Expected Answer	Mark	Rationale/Additional Guidance
4	(a)	1 clamp work to a machine table. Single-acting cylinder	[1]	
		2 operate a hopper sliding door. Double-acting cylinder	[1]	
	(b)	Give three other practical applications that use the type of cylinder shown in Fig. 3 (a). Examples include: <ul style="list-style-type: none"> • Operating a micro-switch • Opening a valve • Removing components from a conveyor belt • Opening a vehicle sliding door • Car Jack 	[3]	Accept any two correct applications
	(c)	Describe in detail, with the aid of a labelled diagram, how two 3-port valves can be used to operate a double acting cylinder. Accept any correct response An example is given		Award one mark for correct component drawing which must include 3 port valve and double acting cylinder. Award one mark for correct connections Allow for minor errors in component drawing or connections

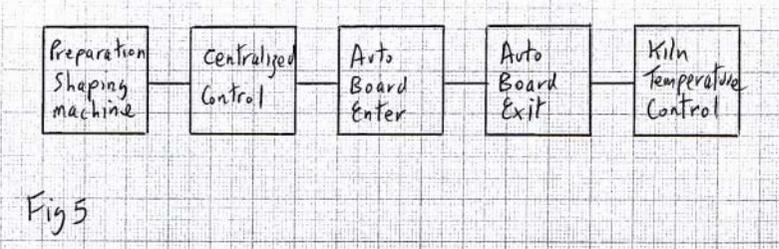
Question	Expected Answer	Mark	Rationale/Additional Guidance
	<p>Q4c</p>  <p>Fig. 3</p> <p>Labelled diagram</p> <p>The control valve is a double pressure operated 5-port valve. The pilot valves are push operated spring return 3-port valves.</p> <p>When the 'in' valve is pressed and released, an air signal is sent to signal port 1 2 of the 5-port valve. Main air leaves at port 2. The cylinder moves negative. Because of the spring, the air signal is removed when the press button is released.</p> <p>When the 'out' valve is pressed, an air signal appears at signal port 1 4 of the control valve. Air leaves at port 4. Main air moves the piston positive.</p>	<p>[2]</p> <p>[3]</p>	<p>Description must include references to</p> <ul style="list-style-type: none"> • three port valves • a five port valve • a double acting cylinder
<p>5 (a)</p>	<p>Give the meaning of the term 'data signal processing'.</p> <p>Data signal processing is when a signal is changed Because it is in an unsuitable format for use in the next part of the system</p>	<p>[1]</p> <p>[1]</p>	

Question	Expected Answer	Mark	Rationale/Additional Guidance
(b)	<p>Give three advantages of using a wave guide as compared to a two conductor type cable</p> <p>Examples include:</p> <ul style="list-style-type: none"> • Waveguides are considerably less complicated than a two conductor cable in their manufacture and maintenance • Moisture is not a severe problem as with coaxial cables • Do not need gas filling • There are no concerns with proper conductor-to-conductor spacing, or of the consistency of the dielectric material, since the only dielectric in a waveguide is air. 	[3]	Accept any three correct responses

Question	Expected Answer	Mark	Rationale/Additional Guidance
(c)	<p>Explain in detail, with the aid of a labelled diagram, the form of wave guide that uses a transverse magnetic mode of signal propagation.</p>  <p>TM mode diagram and labels</p> <p>When an electromagnetic wave propagates down a hollow tube, only one of the fields -- either electric or magnetic -- will actually be transverse to the wave's direction of travel.</p> <p>The other field will "loop" longitudinally to the direction of travel, but still be perpendicular to the other field.</p> <p>Whichever field remains transverse to the direction of travel determines whether the wave propagates in <i>TE</i> mode (Transverse Electric) or <i>TM</i> (Transverse Magnetic) mode.</p>	[2]	<p>Award one mark for correct labels Award one mark for correct drawing</p> <p>Allow for minor errors in drawing or labels</p> <p>Explanation must include references to</p> <ul style="list-style-type: none"> • type of field • wave direction of travel • signal propagation
Total		[10]	

Question		Expected Answer	Mark	Rationale/Additional Guidance
6	(a)	<p>Name two of the main units used in a programmable logic controller (PLC). Examples include: Programme memory Data memory Output devices Input devices</p>	[2]	Accept any two correct main units
	(b)	<p>Give three practical application of a PLC. Examples include: metal machining sequences product assembly lines batch chemical processes motor car manufacture using robots control of pneumatic cylinders</p>	[3]	Accept any three correct applications
	(c)	<p>Describe in detail, using examples how PLC controllers have had an impact on instrumentation and control systems.</p> <p>Originally a logic control system was 'hard wired' using electronic relays, timers and logical units.</p> <p>The system was inflexible, time consuming and restricted production. Rewiring needed every time for a new application.</p> <p>Today, all of the previously mentioned are almost non-existent. The microcomputer PLC is a robust, reliable instrument with many functions and features including being relatively low cost to purchase.</p> <p>Examples – A Low cost PLC can control medium scale automatic machine stations or chemical batch reactors</p> <p>Large PLC systems are capable of running an entire factory automation system.</p>	[1] [1] [1] [1] [1]	
		Total	[10]	

Question	Expected Answer	Mark	Rationale/Additional Guidance
7 (a)	<p>State two features that you would expect to find on a system that is monitoring a factory production line.</p> <p>Examples include:</p> <ul style="list-style-type: none"> • Automatic alert or alarm • Stop buttons placed in strategic positions • Easy to programme alarm panel • LCD remote keypad • Yes or No screen prompts to programme individual settings • Factory preset programming should suit 90% of purposes • Uncomplicated system for adding on any other desirable features that might be needed after the production line has been used 	[2]	Accept any two correct features
	<p>(b) Explain why it is often necessary to include video cameras in a production line system.</p> <p>Examples include:</p> <ul style="list-style-type: none"> • to observe good and bad working practices so that safety is not compromised. • to check that all systems are functioning correctly • to carry out diagnostic checks on any part of the production process • evidence suggests that a properly installed and managed security camera system can dramatically reduce crime levels. • drops as high as 90% have been recorded. from the camera a record of the time of an attempted crime can be found and faces are often be seen which can lead to the arrest of a person and a subsequent court case 	[3]	Accept any three relevant points Allow two marks for single justified point

Question	Expected Answer	Mark	Rationale/Additional Guidance
(c)	<p>Describe in detail, with the aid of a labelled block diagram, a monitoring control system used in engineering.</p> <p>An example is provided below:</p>  <p>Correct diagram Correct labels</p> <p>The production line uses the advanced Distributed Control System (DCS) The process divided into five parts, distribution shaping, central control, automatic board enter, auto board-exit and drying kiln temperature control. The parts are monitored by DCS monitor system all the time having five parts shown in the block diagram</p> <p>Preparation shaping machine: screw conveyer, pastes pump, metering pumps, feeding screw conveyer, slurry mixer, forming station mixer, platform shaking machine and ring belt forming machine.</p> <p>Centralized control system: deals with data acquisition and processing also monitors the shaping and drying process.</p>	<p>[1] [1]</p>	<p>Award one mark for correct labels Award one mark for correct diagram (accept system diagram in place of a block diagram)</p> <p>Allow for minor errors in diagram or labels</p> <p>Description must include references to</p> <ul style="list-style-type: none"> • details of input • details of process • details of output

Question		Expected Answer	Mark	Rationale/Additional Guidance
		<p>Auto board-enter system: auto board cutter, belt conveyor, roller, board turnover machine, kiln enter distributor, faster board-enter, through PLC auto control, the process of cutter, speed-up, kiln enter of gypsum board is finished</p> <p>Automatic finished board system: board-exit from dryer, layer-distributor, horizontal belt conveyor, roller, cutter and stacking machine. All controlled by a central system through sensor, PLC, touch screen and control panels. Cutting, taping and stacking are finished automatically. Drive, temperature control, and hot air cycling system: Control is through a remote meter and humidity sensor system</p>	[3]	
8	(a)	<p>Give the meaning of the term 'simulation of electronic circuits'. Electronic circuits can be designed and tested on screen.</p>	[1] [1]	
	(b)	<p>Give three benefits of using simulated circuits.</p> <p>Examples include:</p> <ul style="list-style-type: none"> • Computerised simulation software can be used to test circuits without the need to physically build them. • The computer simulation can save space in storage. • Physical components are not required, so money isn't wasted on expensive parts • Can speed up production processes. • The circuit can be edited, which makes it easier and cheaper to modify your design as you go along. • PCB's can be tested before construction 	[3]	Accept any three correct benefits

Question	Expected Answer	Mark	Rationale/Additional Guidance
(c)	<p>Explain in detail, how circuit boards can be produced in real time using Computer Aided Manufacture (CAM).</p> <p>When a Printed Circuit Board layout has been designed using CAD, the board can be produced or manufactured using CAM.</p> <p>Two examples of using CAM are: A design machined by a computer numeric control (CNC) miller, which removes unwanted copper from the board or A design layout printed onto acetate and transferred to a copper-clad board using the photo transfer method. The unwanted copper is chemically removed.</p>	[5]	<p>Explanation must include references to</p> <ul style="list-style-type: none"> • the type of process used • the role of the computer • auto routing of tracks • blocking together of circuits • real time considerations
Total		[10]	

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