H Engineering Contexts & Challenges

Types of Engineer

Civil Engineer

Civil engineers deal with infrastructure. They plan, design and oversee the construction and maintenance of building structures and facilities such as roads, railways, bridges, dams, irrigation projects, power plants, and water and sewerage systems.

Chemical Engineer

Chemical engineers deal with the chemical properties of materials and how these can be changed or altered for specific jobs. This could be from coating metal with something to make it more water and rustproof, to making plastic from oil.

Electrical Engineer

This branch of engineering can be thought of to include not only electronics but also power generation and distribution, motors and electromechanical devices. It concerns itself with power generation, transmission, utilisation and measurement.

Electronics Engineer

Although the name is similar to electrical engineering, it is different. Electronic engineering is about automatic control and the implementation of it. It encompasses analogue and digital circuits as well as computer programming.

Environmental Engineer

This branch concerns itself with protecting life - from adverse environmental effects such as pollution. Environmental engineers work to improve recycling, water and air quality, waste disposal and public health.

Mechanical Engineer

Mechanical engineers concern themselves with anything that moves. They design and develop mechanical devices to complete specific jobs.

Structural Engineer

Structural engineers analyse, design, plan and research structures, ensuring that a structure is dafe and can support the needed weight. They are trained to understand and calculate the stability, strength and rigidity of a structure, ensuring that it will not collapse under certain loads, forces or conditions.

Impacts of Engineering

Social Impacts

- Are there increased employment or training opportunities created through this engineering project?
- Will there be improved infrastructure because of it?
- Will there be traffic disruption because of its creation?
- Will there be disturbances because of noise?

Environmental Impacts

- Could this provide habitats for wildlife?
- Will there be a risk of damaging animal habitats or ecosystems?
- Will there be a loss of green belt? Will nature be destroyed/damaged because of it?
- Will there be a risk of danger to animals because of this engineering solution?
- Will there be more demand on water or power services?

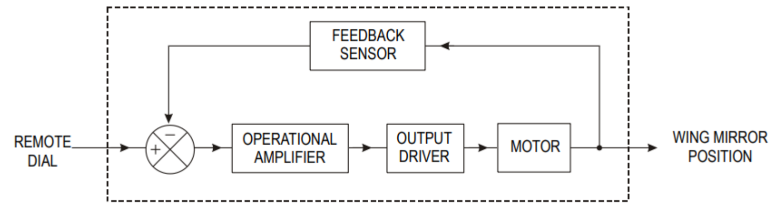
Economic Impacts

- Will this engineering solution bring money into the local area through tourism or other means?
- Will this attract other companies to invest in the area?
- Will this employ more people, meaning more money spent on the local area?

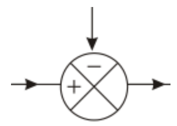
Emerging Technologies

You need to know about emerging technologies that are currently being developed and are not yet commercially available. As technology is always rapidly changing, you should research some emerging technologies in advance of any exams so you are up to date with current developments.

Control

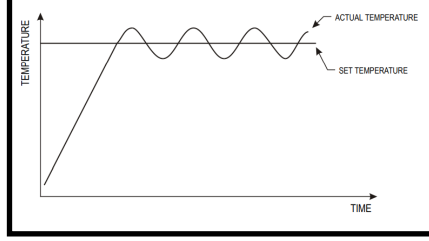


In closed loop control, the output value is constantly monitored and compared to the desired (or reference) value. If a difference exists between the "actual value" and the "reference value", it realises that an error has occurred and will change the input into the system to

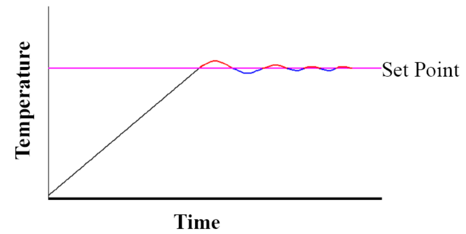


When drawing an error detector in a system diagram, you must always make sure the + is connected to the desired input and the

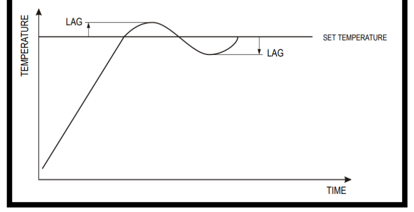
Any system using an Op Amp as a comparator is known as two-state closed-loop control. The desired output it rarely met because the system is either on or off.



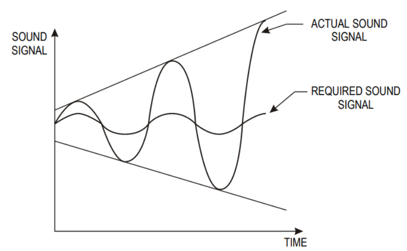
A difference amplifier amplifies the difference between the reference level and feedback signal. This helps to prevent the "overshoot" and "time lags" that can be seen in a comparator-based system. Because of this it allows for the desired output to be reached, as the difference between the two signals will eventually be 0.



Negative Feedback



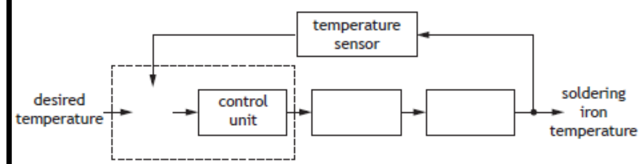
Positive Feedback

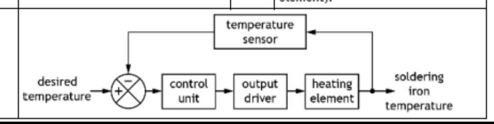


5. A variable temperature soldering iron is shown.

The soldering iron uses a two-state control system to turn the heating element on and off, and to monitor its output to maintain the desired temperature.

Complete the control diagram for the soldering iron below. 3



5.				3	1 mark for error detector, negative feedback configuration. 1 mark for output driver (or driver/transistor/MOSFET/Transducer Driver/TD). 1 mark for heating element (or element).
					

Energy & Efficiency

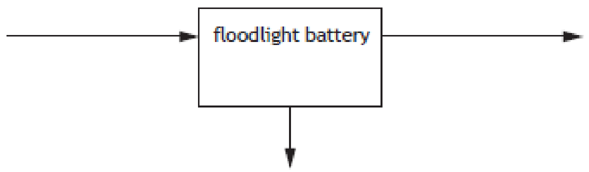
Work Done	$E_{WD} = F \times d$	Energy (J)	Force (N)	Distance (m)	
Weight	$W = m \times g$	Weight (N)	Mass (kg)	Gravity (9.8 ms^{-2})	
Power	$P = \frac{E}{t}$	Power (W)	Energy (J)	Time (s)	
Electrical Energy	$E_e = ItV$	Energy (J)	Current (A)	Time (s)	Voltage (V)
Kinetic Energy	$E_K = \frac{1}{2}mv^2$	Energy (J)	Mass (kg)	Velocity (ms^{-1})	
Potential Energy	$E_P = mgh$	Energy (J)	Mass (kg)	Gravity (9.8 ms^{-2})	Height (m)
Heat Energy	$E_h = cm\Delta T$	Energy (J)	Specific Heat Capacity ($Jkg^{-1}K^{-1}$)	Mass (kg)	Change in temperature (°C)
Elastic Strain Energy	$E_s = \frac{1}{2}Fx$	Energy (J)	Force (N)	Extension (m)	
Efficiency	$\eta = \frac{E_{out}}{E_{in}} \times 100\%$ $\eta = \frac{P_{out}}{P_{in}} \times 100\%$				

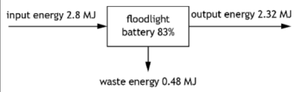
8. (continued)

Battery powered portable floodlights are to be installed on the construction site to allow work to be completed in lower light levels.

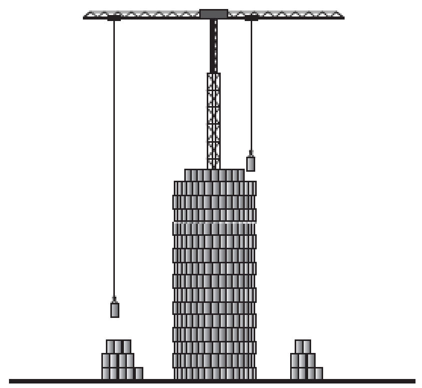
The battery is rated at 15 V, 13 A. In 4.0 hours, the useful output energy is 2.32 MJ.

(b) Complete the energy audit diagram for the portable floodlight battery, showing the input and output energies, efficiency, and waste energy. 3



	(b)		E_{in} = 15 × 13 × (4 × 60 × 60) = 2808000 J = **2.8 MJ (2 sf)** Waste energy = 2800000 - 2320000 = **480000 J (2 sf)** Efficiency = 2320000 / 2800000 = 0.8285714286 = **83% (2 sf)** 	3	1 mark for calculating input and waste energy (no unit required). 1 mark for calculating efficiency (unit as appropriate). 1 mark for completing diagram correctly.

7. An engineering team has produced a prototype system to store excess energy from power plants.



When electricity production exceeds demand, electric motors are used to lift concrete blocks and place them in 'towers'. When the blocks are returned to ground level electricity is reclaimed by generators.

The first block has a mass of 10,000.0 kg. The system that raises this block is 92% efficient.

(a) Calculate the energy required to raise this block 32 m. 2

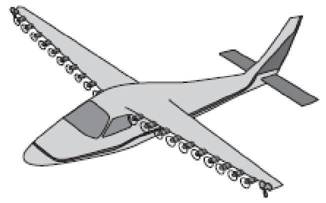
A second block applies a force of 80.0 kN to the supporting wire rope.

As this block is returned to ground level (at constant speed) its supporting wire rope turns a generator and electricity is reclaimed. This part of the system is 87% efficient.

(b) Calculate the power output from the generator if this block descends 15 m in 11 seconds. 3

7.	(a)		E_{out} = 10000 × 9.8 × 32 = 3136000 J E_{in} = 3136000/0.92 = 3408695.65 = **3.4 MJ (2 sf)**	2	1 mark for correct energy out (unit not required) 1 mark for correct energy in with unit
	(b)		E_{in} = 80000 × 15 E_{in} = 1200000 J P_{in} = 1200000 /11 = 109.090909 kW P_{out} = 109.090909 × 0.87 = 94909.0909 = **95 kW (2 sf)** **Alternative method** E_{in} = 80000 x 15 E_{in} = 1200000 J E_{out} = 1200000 x 0.87 = 1044000 J P_{out} = E_{out} / t = 1044000 / 11 = 94909.09 = **95kW (2 sf)**	3	1 mark for correct energy in (units not required) 1 mark for correct power in (unit not required) 1 mark for correct power out (with unit) 1 mark for correct energy in (units not required) 1 mark for correct energy out (units not required) 1 mark for correct power out (with unit)

7. A prototype of an electrically powered aeroplane is being developed and tested by a team of engineers.



The aeroplane is powered by 22 motor-driven propellers that each supply 18 kW.

(a) Calculate the rotational speed of each motor if it produces 23 N m of torque. 1

When operating at full power the aeroplane is 73% efficient. The aeroplane's battery stores 320 MJ when fully charged.

(b) Calculate how much time the aeroplane can run at full power before the battery runs out. 2

Improving efficiency is a key task for the engineers who design the aeroplane.

(c) Explain **one** economic and **one** social impact of improving the efficiency of the aeroplane. 2

Economic______________________________

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Social______________________________

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When the aeroplane lands, the propellers are used to transform its kinetic energy back into electrical energy to recharge the batteries as part of a regenerative braking system.

The combined mass of the aeroplane and passengers is 4800 kg and the regenerative braking system is 64% efficient.

(d) Calculate the energy recovered if the aeroplane's velocity changes from 95 $m s^{-1}$ to 25 $m s^{-1}$. 3

7.	(a)		P = 2π × n × T n = 18000 / (2 × 3·14 × 23) n = 124·6192191 n = **120 rev sec^{-1} (2 sf)**	1	1 mark for answer with units.
	(b)		Power required from battery = (22 × 18000) / 0·73 = 542465·7534 W t = E/P t = 320000000 / 542465·7534 t = 589·8989899 t = **590 s (2sf)**	2	1 mark for power. 1 mark for time with unit.
			Energy out = Energy In x eff = 320000000 x 0.73 = 233600000 J Time = Energy / Power = 233600000 / (22 x 18000) = 589.8989899 = **590 s (2sf)**		1 mark for energy. 1 mark for time with unit.
	(c)		Economic: Reduces running cost due to less electricity being used. Social: Longer flight times would be possible allowing people to travel further without stop-over. Since the aeroplane is more efficient people will use the airline as they are helping the environment.	2	1 mark for one economic relating to efficiency. 1 mark for one social relating to efficiency. Must have a cause and an effect for 1 mark. Credit should be given for any other suitable response which is an explanation.
	(d)		E_k = 0·5 × 4800 × (95^2-25^2) = 20160000 J E_k = (0·5 × 4800 × (95^2))-(0·5 × 4800 × (25^2)) = 20160000 J E_e = 20160000 × 0·64 = 12902400 = 13000000 J = 13 MJ (2 sf)	3	1 mark for the difference between 95 and 25 (either as shown or through finding the difference between two separate E_k calculations) 1 mark for calculation of E_k (no units required). If candidate does E_k= 0·5 x 4800 x 70^2 E_k = 11760000 (1 mark for E_k) E_e = 7526400 = 7.5 MJ (1 mark for E_e) 1 mark for E_e, **units required.**