AS Design Engineering specimen paper model solution ('June 2016')

1a)

The camera is located at the bottom to lower the centre of gravity in order to improve the stability of the drone when it is flying.

1b)

i) The controller receives inputs from three sensors and uses these to control the output of the motor.

ii) The altimeter provides data about the altitude of the drone and the controller compares this to the desired altitude value. If the altitude is wrong, the controller adjusts the motor speeds which changes the altitude. The new altitude is fed back to the altimeter and the process repeats.

1c)

Below are all the possible options for answers:

- ABS has good impact resistance so it is less likely to crack should the drone collide with obstacles.
- ABS has a high strength to weight ratio (□) so that the body has good tensile strength without adding unnecessarily to the weight of the aircraft
- ABS is a good electrical insulator so that there is no chance of short circuits between electrical components which may be mounted to the casing.
- ABS is not affected by the sun or rain and does not become brittle in low outdoor temperatures so it will be durable for outdoor use around the year.
- ABS is a thermoplastic so it can be injection moulded into the complex shapes for the drone body, allowing for larger scale production at low cost.
- ABS can be given a high quality finished during the moulding process which will enhance the drone's image and give user appeal.

1d)

i) Weight = mass x gravitational field strength

W = 3/2 x 9.8
W = 14.7N

ii) 250 mm ÷ 2 = 0.125m

$$P = \frac{0.18 \times 14.7(\frac{3}{2})}{0.125*}$$

= 81.16 W

I = P/V or equivalent
I = 81.16* / 11.1
I = 7.31 A

1e)

Negative issues:

- Drones can be used to fly over private land which poses security and privacy issues, and they can then take photos or stream live video without people knowing, e.g. they have been used to photograph celebrities sunbathing.
- Drones can be used for illegal or irresponsible purposes where other methods put the user at greater risk of being caught, e.g. they have been used to deliver drugs and other illegal items to prisoners inside prison.
- Drones are heavy airborne machines which can be dangerous if they hit people or property. This can happen with inexperienced or irresponsible pilots or in situations where drones are being flown in busy public areas built-up areas, e.g. parks or towns.
- Badly maintained drones can fail in flight and fall out of the sky posing significant risk of damage or injury, e.g. propellers frequently come off or badly maintained batteries will fail with very little warning.
- There have been reports of irresponsibly flown drones endangering aircraft on final approach, and drones being flown at farm animals which causes worry and is cruel.
- There are signs that drones might be starting to replace certain workers' jobs at much lower cost, e.g. taking aerial photos, which would normally involve a pilot in a helicopter or plane, or Amazon.com developing their aerial delivery service, which obviously replaces delivery drivers.
- Pilotless aircraft have become associated with military strikes, and this 'killing at a distance' is considered immoral by some people, e.g. US military drone attacks in Afghanistan.
- they can be fitted with 'FPV' cameras which allow the pilot to wear goggles to give them a 'pilots-eye view'. This allows the drone to be flown completely out of direct sight of the pilot which exacerbates the security issues and could result in the drone being flown out of radio control range.

Positive issues:

- Drones can be used to carry items into, or photograph in locations which would normally not be accessible, e.g. to photograph and drop equipment in treacherous conditions to support aid and rescue work.
- Drones can be used to monitor issues from an aerial perspective that may not be easy to observe or understand from the ground, e.g. monitoring deforestation, conservation or environmental impact in a certain situation.
- Drones can be used to offer security surveillance and observe crowd behaviour from an aerial perspective giving valuable information that cannot be made from the ground.

2a)

i) Male 51mm, Female 47mm
Average thumb length = (51 + 47) / 2 = 49

Measurement A = 1.2 x average thumb length
Measurement A = 1.2 x 49*
Measurement A = 58.8 mm (Allow 59 mm)

ii) 65mm length is 2mm less than 50% percentile

Percentile range 50 – 5 = 45%
Forefinger length range 67 – 60 = 7mm
45 ÷ 7 = 6.42 % per mm

6.42* x 2 = 12.86
50 – 12.86 = 37.14%

2b)

Strategy to ensure wider user appeal of the games controller, e.g.:

User-centred approach, in which extensive attention is given to the needs and wants of the games controller users of both genders.

Other possible strategies:

- Aesthetic neutrality, in which the shapes, sizes, colours used do not bias towards either gender, e.g. could refer to shape of hand-holds not being 'male' or colour of casing not being 'female'.
- Ergonomic neutrality, in which the dimensions, layout of controls, etc. do not favour either gender, e.g. large forces needed to operate controls, inability to press buttons with long fingernails.
- Consideration of the system design, so that the components, modules and interfaces do not bias towards gender.
- Software design, where the functionality of the controller does not favour or discriminate against either gender.
- Marketing and branding focus, in which both genders are evenly represented and the appeal of the controller is demonstrated to be equal between both sexes.

2c)

i) Mass = volume x density

Mass = 80 x 1.08 = 86.4g (0.0864kg)
Cost per kg = 50 ÷ 20 = £2.50
Cost for 50 000 casings = 50 000 x 0.0864* x 2.5 = £10 800

ii) The volume will be reduced by 0.75 x 0.75 = 0.5625

Therefore, the new volume will be 80 x 0.5625 = 45cm3

3a)

Analogue and digital sensors and how the data from each sensor is used to assist the cleaning operation, e.g.:

- Analogue - an infra-red distance sensor could be used to measure the distance between the robot and an obstacle so that the robot does not have to bump into the obstacle to detect it, which avoids damage to furniture (and robot).
- Digital – dirt bin level sensor which would give a logic 1 signal to indicate the dirt bin is full; this would tell the robot to stop cleaning and sound an alert.

Other possible sensors include:

<u>Analogue:</u>

- Ultrasonic rangefinder – measures distance by reflecting high frequency sound pulses off the obstacle and timing the delay (SONAR), this provides data for the robot which allows it to slow down and manoeuvre around obstacles which avoids the need for reversing.
- Battery voltage level sensor – informs the robot about the condition of the battery and allows it to calculate the time remaining before needing recharging.

<u>Digital:</u>

- Dirt bin correctly in place sensor – will stop the robot and sound an alert if the dust bin is not securely in place.
- Cleaning brushes sensor – would indicate whether the brushes are rotating or not, which could be used to sense if the brushes become obstructed.
- Push buttons on control panel – each button is a digital sensor which, when pressed, sends a logic 1 signal to the microcontroller which will then respond appropriately.

3b)

How speed and direction are controlled, e.g.:

The speed can be controlled by controlling the current through the motor (or, varying the voltage across the motor).

The direction is controlled by reversing the current flow, which can be done with a DPDT relay:

Other possible speed control responses include:

- Voltage applied to the motor is varied.
- A pulse width modulation (PWM) method can be used.
- The analogue output pin from a microcontroller can be used.

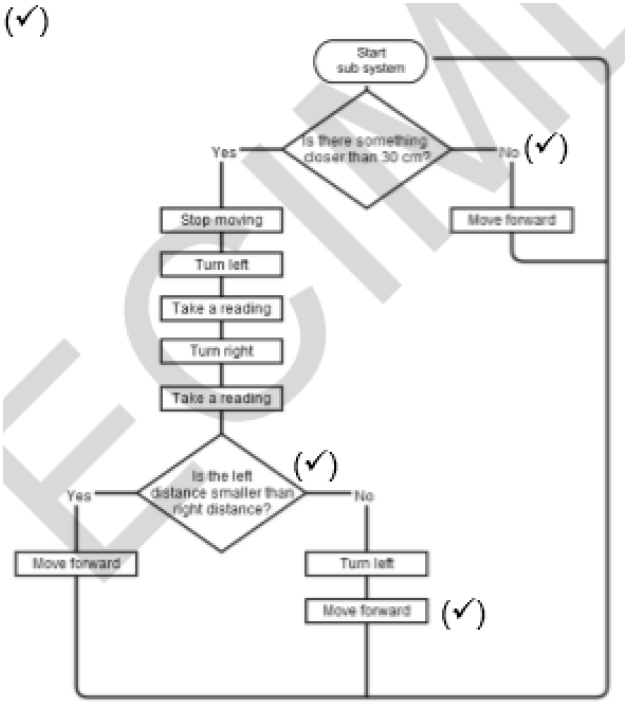
Other possible direction control responses include:

- The current is reversed.
- The applied voltage is reversed.
- An H-bridge driver (motor driver ic) can be used.

3c)

Symbol	Name	Function
	Start/end	An oval represents a start or end point
	Arrows	A line is a connector that shows relationships between the representative shapes
	Input/Output	A parallelogram represents input or output
	Process	A rectangle represents a process
	Decision	A diamond indicates a decision

(✓)

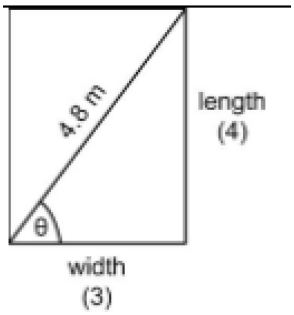


(✓) (✓) (✓)

3d)

Distance = speed x time

d = 0.4 x 12 = 4.8m



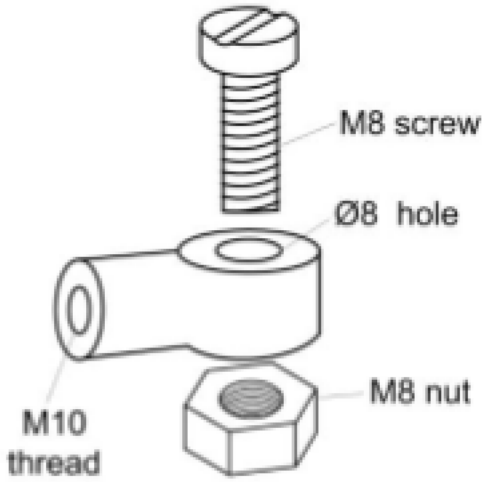
Tanθ = 4/3
θ = 53.1

length = 4.8* x Sin 53.1 = 3.84m
width = 4.8* x Cos 53.1 = 2.88m

4a)

i) Sketches and/or notes may include:

- M10 threaded hole to accept the pushrod end
- Method of connecting to the Ø8 hole on the valve arm
- Connection to valve arm must allow for rotation
- Connection to valve arm must be secure and not able to fall out.



ii) How new technologies can assist the design and manufacture of the linkage, e.g.:

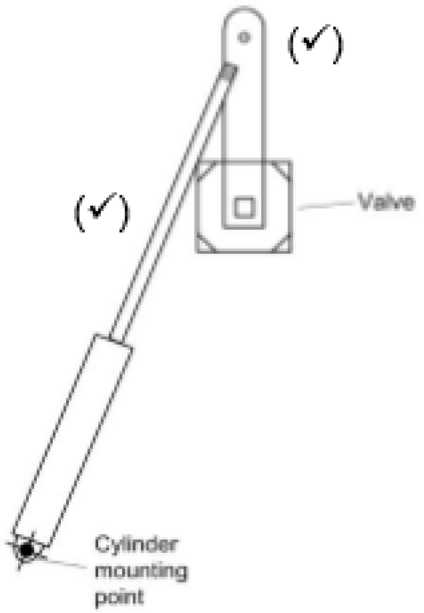
- A digitally designed linkage could be analysed with CAE software, to test material strength/flexing/durability etc.
- New material technology could be explored, to improve the performance, considering the needs of this situation, e.g. strength/flexing/durability/water resistance, low friction.

Other possible responses may include:

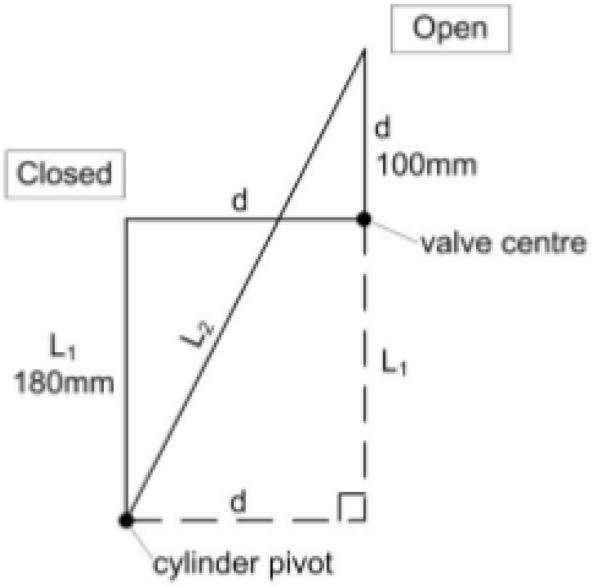
- The linkage could be modelled through the use of 3D rapid prototyping, and this part could then be used in a digital model to test the movement of the mechanical system.
- Once modelled through digital design the file could be sent for 3D printing or CNC machining, which would be a lost cost/high accuracy/fast method of producing the linkage part.

4b)

i)


(✓)
(✓)
Valve
Cylinder
mounting
point

ii)


Open
d
100mm
Closed
d
valve centre
L1
180mm
L2
L1
d
cylinder pivot

(✓)

From the diagram, it is apparent that L2 is the hypotenuse of a right angle triangle with sides d and (L1 + d) (evidence for this can be a clearly drawn diagram).

$L_2^2 = d^2 + (L_1 + d)^2$ (✓)
$L_2^2 = 100^2 + (180 + 100)^2$
$L_2^2 = 88400$
$L_2 = 297mm$ (✓)

Cylinder stroke = $L_2 - L_1$
stroke = 297 – 180
stroke = 117mm (✓)

4c)

i) Interface component:

Solenoid valve.

Other possible responses include:

- Electrically-operated valve
- Solenoid 3/2 valve
- Electromagnetic valve

ii)

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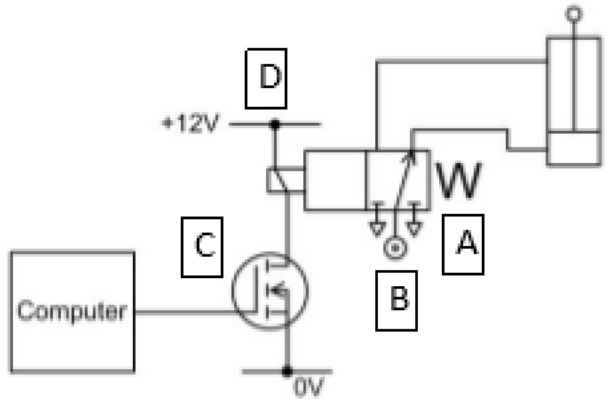

The diagram should show clear evidence of:

A) solenoid valve to control air to the two ends of the cylinder. This would be a 5/2 valve for a double acting cylinder
B) The air supply and exhausts should be shown
C) A current driver between the computer output port and the solenoid valve. This might also be named as a MOSFET, darlington or relay
D) The power supply for the solenoid valve should be shown interconnected with the driver and the solenoid valve.

4d)

Indicative content:

- Rigorous, recurring and progressive testing, modelling and development, with user feedback' of prototype solutions helps to achieve the fit for purpose outcome.
- The design would be modelled in a development area, using the actual valve and cylinder components to test that the air pressures and forces generated are sufficient to overcome friction and operate the valve. This will identify any required modifications to improve the design solution.
- User testing and location testing can be used at throughout the process to obtain feedback that identifies where the user foresees issues with the system. This will lead into consideration of modifications in line with stakeholder requirements.
- CAD could be used to model the entire system before manufacture of parts or assembly of system components. This allows clearances to be checked and distances to be finalised before final fitting on site.
- The modelled system can be soak tested, i.e. continually cycled for several thousand operations to generate a rough idea of system life expectancy. The outcomes from this testing can be analysed to identify areas of improvement that need to be made in future iterations of the product development.
- The software for the controller can be developed, debugged and tested with the user before installing into the laundry system. User feedback can be very useful for further developing the solution.

5a)

Reasons why design engineers would consider environmental impact, e.g.:

The choice of whether to use raw resources to manufacture parts or use recycled or reused material. There is always an option to use recycled pellets in a thermopolymer product the for instance – this option would not be available if a thermosetting polymer was chosen. In order to minimise the amount of material used, the design engineer may consider the quantity of material used to manufacture parts, reducing quantities where possible. This will result in less material taken from their source, particularly when from a non-renewable source.

Other possible environmental impact considerations during manufacture could be:

- the choice of a manufacturing system/company with a low carbon footprint and/or low pollutant emissions which might attract a financial bonus linked with an environmental incentive
- end of life considerations - designing the product to be manufactured in a way which makes it easily separable into component parts for recycling at end of product life. This is attractive to stakeholders and may attract financial incentives

5b)

Indicative content:

- The initial growth in popularity will be linked to the initial demand for the product. The inclusion of special features or USPs may promote the initial popularity.
- The rate of growth will be limited if demand exceeds supply, which could occur if the manufacturing rate is too low or if insufficient stock is generated before product release.
- Rate of growth will also be affected by advertising methods and by brand image.
- Sustaining a product's popularity will be linked with customer's reaction to the quality of the products when they are first released. Customers leaving good product reviews on e-commerce websites will inevitably promote ongoing sales, and vice versa.
- Maintaining popularity may be linked with fashion, especially if the product's design is linked with a trend or a modern technology, e.g. there was a trend for wind-up torches a few years ago which has waned in recent times.
- Eventual product decline will be linked with the product's technology becoming obsolete, e.g. lighting products with incandescent bulbs are rarely sold now because low energy LED bulbs mean that batteries last longer, and a brighter light is produced. Fashion, cost and product reputation will all play a part.
- Stakeholders have an interest in some products due to the knowledge that the materials and processes used have consideration of fairtrade, or come from reliable managed natural sources.