



DESIGN AND TECHNOLOGY

0445/41

Paper 4 Systems and Control

October/November 2016

MARK SCHEME

Maximum Mark: 50

Published

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Section A

1 (a) Dial Gauge / dial indicator gauge / clock gauge, 1 mark. [1]

(b) Deflection, flexing, allow bending, 1 mark. [1]

(c) The deflection will be reduced if the beam is turned through 90°, so that the narrow edge is resting on the supports or movement of supports **A** and **B** closer together,

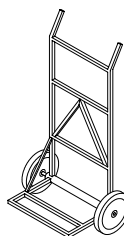
Allow use of additional support.

Method used, 1 mark. How method reduces movement, 1 mark. [2]

2 (a) The barrow uses a **first order** or **first class** lever, 1 mark. [1]

(b) These areas could be reinforced:

- Back
- Base
- Base to back angle



Allow struts, webs, gusset plates.

2 × 1 marks for suitable reinforcement. [2]

3 (a) Silver is the conductor. [1]

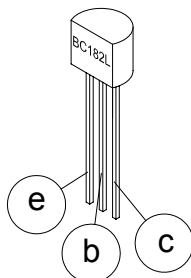
(b) Responses could include:

- Wood will contain varying amounts of moisture reducing its resistance
- Wood can burn if there is a fault in the circuit.

Allow other valid reasons.

1 mark. [1]

4 (a) (i) 1 correct, 1 mark. 2 or 3 correct 2 marks.



[2]

(ii) **Emitter**, 1 mark.

[1]

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- (b) Advantages for larger tracks and pads could be:
- Less chance of breaks in track when etching
 - Less chance of drill slipping and breaking through pad
 - Larger drill size can be used
 - Can carry higher current
 - More area to solder.

2 × 1 marks for suitable advantages. Allow other valid responses.

[2]

5



Voltmeter



Motor



Ammeter

1 mark for each correct

[3]

6 Power sources could be:

- Compressed air
- Mains electricity
- Battery, either dry cell, rechargeable or lead acid
- Renewable sources, solar power, wind turbine, windmill, watermill
- Fossil fuels
- Clockwork / spring
- Gravity
- Manual power

3 × 1 marks for valid sources. Allow other valid responses.

[3]

7 (a) **Ratchet** and **Pawl**, 1 mark for each.

[2]

(b) Ratchet and pawl are used to prevent the drum from unwinding when there is a load on it; they allow only one way movement.

Allow mark for understanding shown.

[1]

8 **Rotary** to **Linear**, allow 'circular' or 'rotating' for rotary and 'straight line' for linear.

[2]

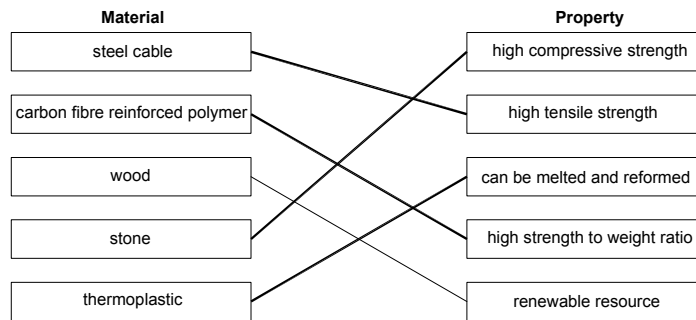
[Total: 25]

Section B

Answer **one** question from this section.

9 (a) 1 mark for each correct.

[4]



(b) (i) The concrete blocks are a counterweight or balancing load, (1), to help maintain equilibrium (1). Allow 'to stop the crane from falling' for 1 mark.

[2]

(ii) **Triangulation** or the use of braces and struts.

[1]

(iii) Turning or twisting force.

[1]

(iv) The forces causing torsion could be from high winds acting on the jib (1) or from the jib accelerating or decelerating during the course of moving a load (1) load swinging (1), 1 mark for each force identified.

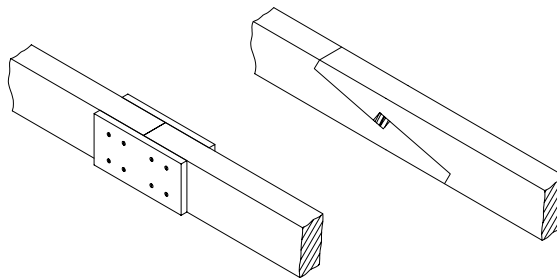
[2]

(c) (i) Joint shown end to end, 1 mark

Recognised principle used, e.g. scarf joint, plates either side, 1 mark

Fixings shown, screws, bolts, wedges, 1mark

Extra components / materials listed, 1 mark.



Maximum 2 marks for impractical / non-functional method.

[4]

(ii) Advantages of a laminated beam could be:

- Defects in timber can be avoided
- Dimensional stability, twisting, bowing does not occur
- Smaller sizes of timber are needed, sustainable timber is used
- Curves can be built into the beam
- Lighter than steel or concrete beams
- High strength / weight ratio, allow stronger than end to end joint.

1 mark for a suitable advantage. Allow other valid responses.

[1]

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(iii) Benefits of method **A** will include:

- Will resist tension on the horizontal arm.
- Vertical load on horizontal arm is transferred efficiently to the vertical piece
- No screws or nails are used.
- Does not rely on the shear strength of screws or nails
- Flush surface.

2 × 1 marks for valid benefits. Allow other valid responses. [2]

(iv) Benefits of method **B** will include:

- Temporary joint can be taken apart
- No cutting in vertical piece needed so strength retained
- Faster joint to produce than **A**
- Vertical position can be adjusted before joint is fixed.

2 × 1 marks for valid benefits. Allow other valid responses. [2]

(d) (i) **Shear**, 1 mark. [1]

(ii) Factor of safety will take into account:

- Yield strength of the material being used
- The static load on the beam
- Expected dynamic load on the beam
- The total loading expected is then matched proportionally to the yield strength of the beam to give a safe working load. E.g. SWL could be 33% of the yield strength.

2 × 1 marks for understanding shown of above points. [2]

(e) Anticlockwise moment = $(450 \times 1.35) + (800 \times 2.25) = 2407.5$, 1 mark

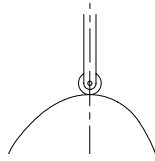
Clockwise moment = $1.8 \times F = 2407.5$, 1 mark

$F = 2407.5 / 1.8 = \mathbf{1337.5N}$, 1 mark

3 marks for correct answer with no working. [3]

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- 10 (a) (i) Roller shown in correct orientation, 1 mark
Edge of roller touching the cam profile, 1 mark. [2]



- (ii) Area C contains dwell. [1]

- (iii) The cam has anti clockwise movement so segments will pass the follower in the order **ABCD**, 1 mark for correct order used.

A, the follower will **fall**

B, slight **rise**

C, **dwell**

D the follower will **rise** to its highest position.

2 × 1 marks for any two of **A,B** or **D** accurately described.

No mark for **C**.

[3]

- (b) (i) 1 mark for each correctly positioned, effort can be anywhere on the handle. [3]



- (ii) Description may include:

- Fluid will be pumped from the master(small) cylinder to the slave(large) cylinder
- The jack will extend
- Fluid drawn from reservoir.

2 marks for valid points or for one point well explained.

[2]

- (iii) Description may include:

- Fluid is allowed back from the slave cylinder into the reservoir
- The jack will retract
- Speed of retraction can be controlled by the relief valve.

2 marks for valid points or for one point well explained.

[2]

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(iv) Reasons for not using pneumatics are:

- Air will compress further so the load on the jack will be unstable
- A ready source of air is needed so the jack would not be fully portable
- Ongoing cost of compressed air
- Difficult to control speed and precision

2 × 1 marks for valid reasons.

[2]

- (c) (i) Explanation to include: Operation of the spray can will be easier because of:
Leverage from the 1st order hand lever, 1 mark
Advantage gained from the gearing 4:1 reduction, 1 mark

Allow 2 marks for detailed explanation of one point.

[2]

(ii) Benefits of nylon gears are:

- No lubrication needed / self-lubricating
- Light weight
- Can be injection moulded at low cost
- Corrosion and chemical resistant
- Reduced wear on gears.

2 × 1 marks

[2]

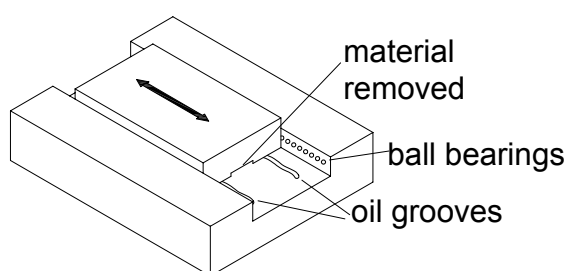
- (d) (i) Friction, 1 mark.

[1]

(ii) Functional mechanical method, 1 mark

Use of lubrication, oil or grease, 1 mark

Clear sketch illustrating method, 1 mark.



3 × 1 marks

[3]

- (e) Thread pitch is **X**, 1 mark.

Thread diameter is **Z**, 1 mark.

[2]

[Total: 25]

11 (a) (i) R1 is the **current limiting** resistor for TR1, allow protective resistor, 1 mark [1]

(ii) R2 is a **pull up** resistor to ensure a logic level at output when transistor is not conducting, 1 mark. Allow reference to switching effect of transistor. [1]

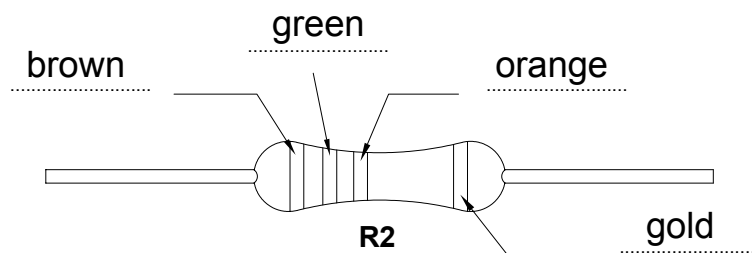
- (iii) Advantages of a transistor switch include:
- No moving parts / no user input required
 - Much smaller than a mechanical switch
 - Fast switching rate
 - No contact bounce
 - No wear or arcing at contacts
 - Low cost when compared to a mechanical switch.

2 × 1 marks for valid advantage. [2]

- (iv) Disadvantages include:
- Low / restricted current carrying capacity
 - Difficulty of replacement if faulty

1 mark for valid disadvantage. [1]

1 mark for each colour correct. [4]



(b) (i) 1 mark for each correct column, 3 × 1 marks. Allow error carried forward on Column X. [3]

A	B	R	C	D	S	X
0	0	0	0	0	0	0
0	1	1	0	1	1	1
1	0	1	1	0	1	1
1	1	1	1	1	1	1

(ii) Dual in line means **two sets**, (1) of pins **parallel to** or **in line** (1) with each other. [2]

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(iii) Benefits of IC holder will include:

- No chance of heat damage to the IC
- Easy replacement of IC
- Easy removal for recycling.

1 mark for a valid benefit.

[1]

(c) (i) **SPST**, 1 mark.

[1]

(ii) **4kΩ**

[1]

(iii) $6.1 = (R2 / R2 + R1) \times 12$, 1 mark

$$6.1 \times R2 + 24.4 = 12 \times R2$$

$$24.4 = 5.9 \times R2 \quad 1 \text{ mark}$$

$$R2 = 24.4 / 5.9 = \mathbf{4.14k\Omega} \quad 1 \text{ mark}$$

Accept a range **4.13kΩ – 4.15kΩ**.

Correct answer with no working 3 marks.

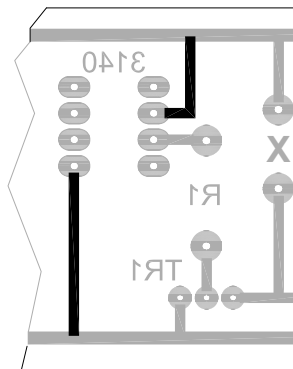
[3]

(iv) If the voltage at the non-inverting input is greater than the inverting input 1 mark
the output will be high, 1 mark.

[2]

(v) Pin 4 to 0V rail, 1 mark.

Pin 7 to +12V rail, 1 mark.



[2]

(vi) **Diode**, 1 mark. Accept D1.

[1]

[Total: 25]