香港考試及評核局
HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY

香港中學文憑考試
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION

練習卷
PRACTICE PAPER

設計與應用科技　　試卷一
科技、設計與社會
DESIGN AND APPLIED TECHNOLOGY　PAPER 1
TECHNOLOGY, DESIGN AND SOCIETY

評卷參考
MARKING SCHEME

(2012年2月29日修訂稿)
(updated as at 29 Feb 2012)

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Question 1

(a)	Analyse the design problem and state the user needs (Full marks be awarded for completion of all the following features):	
	– Clarify the design task	
	– Exploit areas and issues relevant to the design problem	
	– Identify and consider the needs and values of a range of users: including physical, emotional, intellectual and social needs of the target groups	
	– Cultural and environmental issues that may have an impact on the design problem	
	– Effective presentation: e.g. using mind mapping, graph and tables to organize information	6
(b)	Consider appropriate constraints and draw up the design specifications:	
	– Consider appropriate constraints: technology (e.g. sensor), cost, scale of production, safety consideration, energy and resources conservation	3
	– Draw up a design specification by identifying essential criteria (e.g. function, aesthetics, performance requirements, intended standard of quality), and prioritise them in order of importance	3 (6)
(c)	Generate a range of design ideas:	
	– Generate and evaluate a range of design ideas based on the criteria set up in the design specification	4
	– Show evidence of ingenuity and use a broad range of design strategies to generate and refine design ideas	2
	– Describe and justify the design solution(s) in relation to function; appearance; performance; materials / components / sub-systems processes; technological features	4
	– Consider the construction and sizes	2 (12)
(d)	Illustrate your final solution with annotated colour sketch(es):	
	– Annotated sketches	12
	– Colouring techniques	6
	– Main dimensions	2 (20)
(e)	State the appropriate materials used (Full marks be awarded on full answer):	
	– State the appropriate materials used for different components in the final design solution in relation to appearance and technological features	4
(f)	Evaluate your final solution against the design specifications and suggest ways for further improvement (e.g. strengths and weaknesses of design):	
	– Make critical and objective appraisal of the final solution relating closely to the design specifications	4
	– Identify design faults and recommend alternatives or changes	2 (6)
Effective Communication		6
– Good presentation	5 or 6	
– Average Presentation	3 or 4	
– Poor Presentation	0 - 2	
	Total:	60 marks

Question 2

(a) Compare the design features of the three calculators shown in Figure 2(a) – 2(c) with regard to the following aspects:

		Figure 2(a)	Figure 2(b)	Figure 2(c)		
(i)	Special applications	For commercial use	For Educational purposes	For travellers	(1 x 3)	3
(ii)	Energy sources	Alternate current	Batteries	Solar Power	(1 x 3)	3 (6)

(b) State two ergonomic considerations related to the design of a calculator: (Any two of the following:)

- Button design
- Angle size of display panel
- Size and shape of calculator

(1 x 2) 2

(c) With regards to the evolution of technology in calculator design, identify the materials used for the case of the calculators shown above. Suggest one reason for choosing the appropriate material:

Calculator	Figure 2(a)	Figure 2(b)	Figure 2(c)
Material of the case	PVC	Aluminum	Silicon gel
Reason	Anti-electric shock	Durable	Flexible form

(2 x 3) 6

(d) With the aid of a coloured sketch, design a calculator with the theme '35th anniversary of Ocean Park':

- Creativity and feasibility 4
- Graphical presentation 2

Total: 20 marks

Question 3

(a) Compare bottle A and bottle B:

		Bottle A	Bottle B
(i)	Shape of bottle	Traditional design	Elegant and ergonomic in design/ good for griping
(ii)	Design of cap	Minimal use of materials	Can be served as a cup/easy to open

(1 × 4) 4

(b) Two suggestions to strengthen the structure of bottle 'A':

– add ribs to the body of the bottle (Notes 2, sketch 1) 3

– increase the thickness of the material used for the body of the bottle (Notes 2, sketch 1) 3 (6)

(c) Two functions of the concave-shaped bottom of bottle 'B':

– to strengthen the structure

– to give the bottle more stability (when upright) (1 × 2) 2

(d) (i) Three advantages on the new designs:

– save more space after the bottle is twisted

– use less plastics to reduce the amount of material used

– more environmental friendly (1 × 3) 3

(ii) A device to carry four 770ml bottles of water:

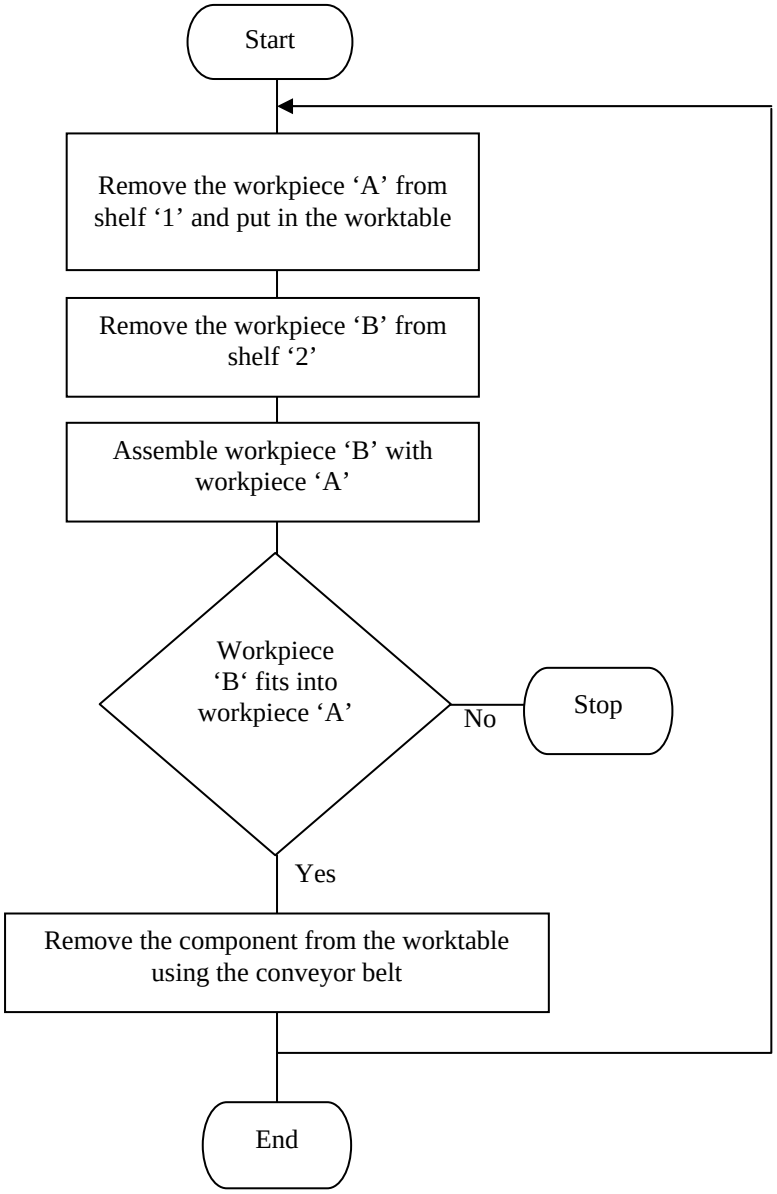
– creativity and feasibility 2

– graphical presentation 3 (8)

Total: 20 marks

Question 4

(a) Flow chart of the robot arm for the assembly work:



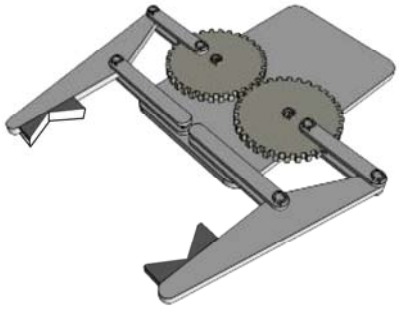
- Correct work flow 7
- Graphical presentation 3 (10)

(b) Give the name of one suitable sensor for part (a):

- IR sensor / Light sensor 2

Question 4 (Cont'd)

(c) With the aid of isometric sketch(es), show the structural principal of the gripper:



- Creativity & feasibility — 6
- Graphical presentation — 2 (8)

Total: 20 marks

END OF PAPER

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練習卷
PRACTICE PAPER

設計與應用科技　　試卷二甲
自動化操作
DESIGN AND APPLIED TECHNOLOGY　PAPER 2A
AUTOMATION

評卷參考
MARKING SCHEME

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Question 1

(a) Input/Output Address Table of the Access Control system for the Entry Lane:

No	Input	Address
3	**Signal from sensor 1 detects the barrier at vertical position.**	I 3
4	**Signal from sensor 3 detects a car has passed the barrier.**	I 4

No	Output	Address
7	**Motor rotates clockwise to raise barrier to vertical position**	O 2
8	**Turns on the signal light to 'FULL'**	O 3

(1 x 4) 4 marks

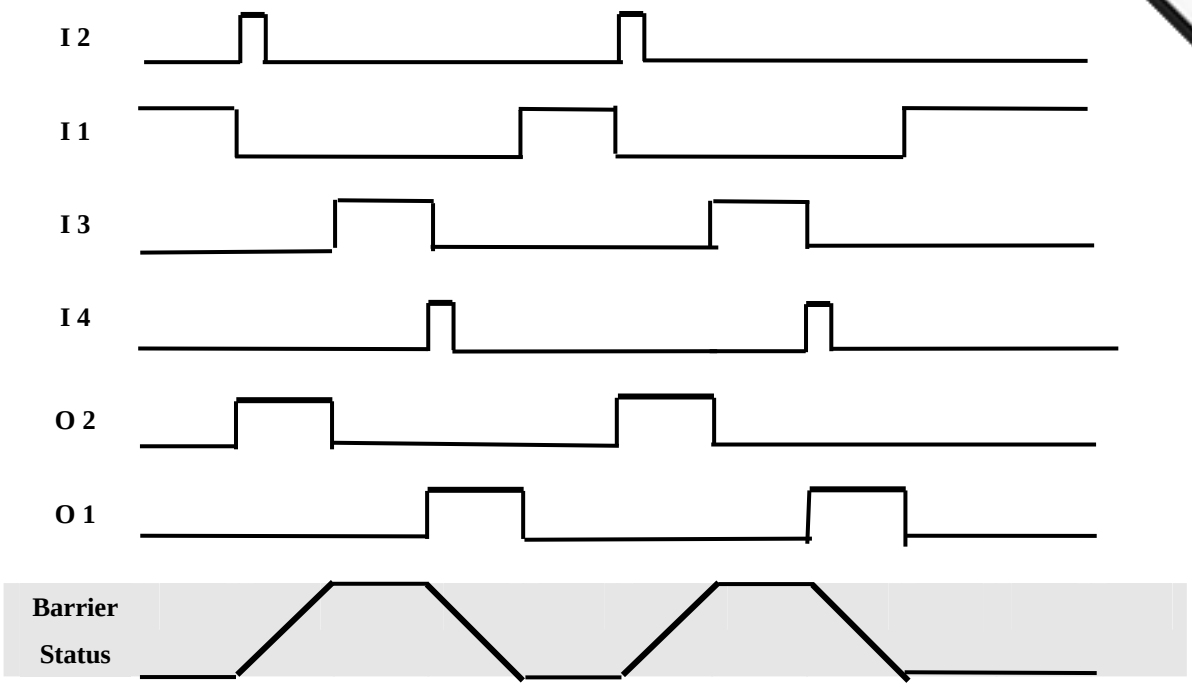
(b) Condition Table:

Sequence	Condition	Active Output
2	• I 2 = 1 • C1(counter output) = 0 • I 1 = 1	**O 2**
3	**I 3 = 1**	**_;_ or NIL**
4	**I 4 = 1**	**O 1**
5	**I 1 = 1**	**_;_ or NIL**

(Condition 2 x 3, active output 1 x 4) 10 marks

Question 1 (Cont'd)

(c) Timing diagram



(1x 8)
8

(d) Safety device – emergency stop 1

Sketch of emergency stop 2 (3)

25 marks

Question 2

(a) 5/2 Directional Control Valve:
- the digit before '/' stands for the number of ports. '5' indicates the valve having 5 ports.
- the digit after '/' stands for the number of positions. '2' indicates the valve having 2 positions.

(1 × 2) 2

(b) Component A - Pressure Regulator 1

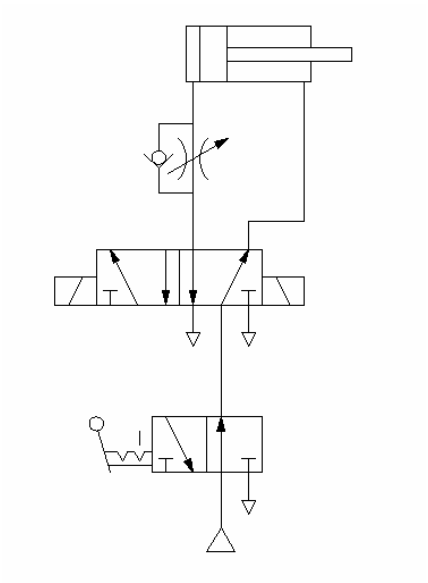
The function of the Pressure Regulator in the circuit is to allow high-pressure air supply line to be reduced to the safe and desirable working pressure for applications. 2

Component B - Flow Control Valve 1

The function of the Flow Control Valve in the circuit is to allow compressed air to flow freely in the direction for extending the cylinder to open the train doors. But it restricts the speed of compressed air flow in the direction to return the cylinder to close the doors at desired speed. 2 (6)

(c) Truth Table:
A = 1
B = 0
C = 0
D = 1 (0.5 × 4) 2

(d) (i) Modified circuit
- correct symbol of the 3/2 valve 2
- correct circuit 3



(ii) Name of the device:
-3/2 control valve 2

Two functions of the device:
- block the air source
- exhaust compressed air (1 x 2) 2 (9)

Question 2 (Cont'd)

(e) (i) Other type of power source and actuator:

- electrical power supply
- DC servo-motor/AC servo-motor 2

(ii) Advantages of using the actuator:
(Any one of the following:)

- Electric supply is **readily available** nowadays.

- If a passenger is caught between a pair of closing doors, the torque **change** could be **monitored with an electrical circuit** and hence corrective action can be taken accordingly. No additional sensor is needed.

- If an isolated pair of doors breaks down, it will not affect the operation of the other pairs of doors of a train carriage.

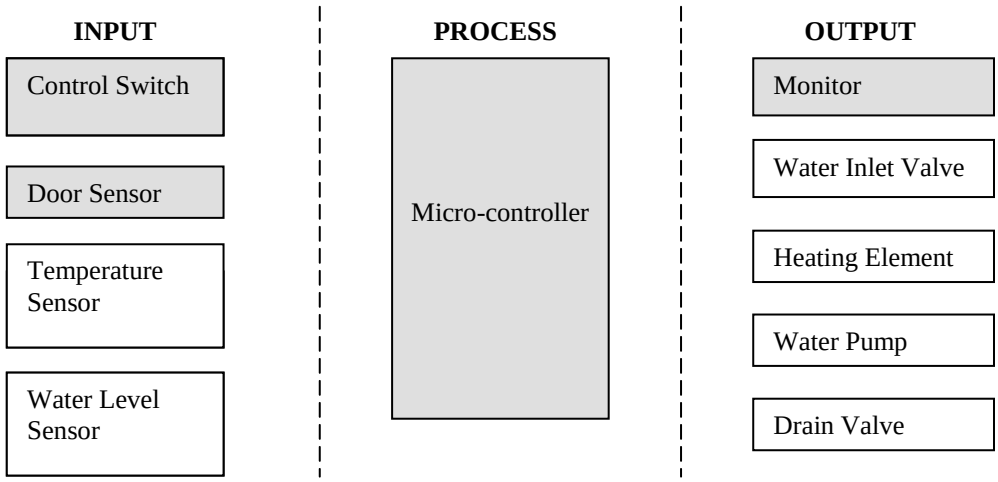
- Electrical system is **flexible for modification and expandable**.

2 (6)

25 marks

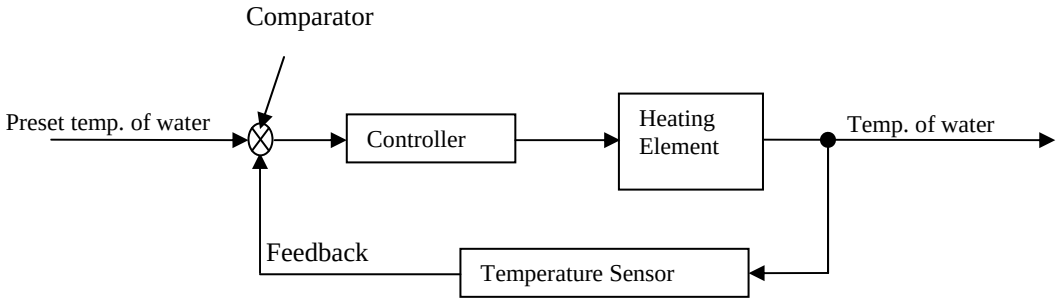
Question 3

(a) (i) Complete the system control diagram of the dishwasher:



(1 × 6) 6

(ii) Draw a closed-loop diagram to show how the temperature of water can be controlled:



- Block of diagram 3
- Annotation (Controller, Heating Element, Temperature Sensor) (1 x 3) 3

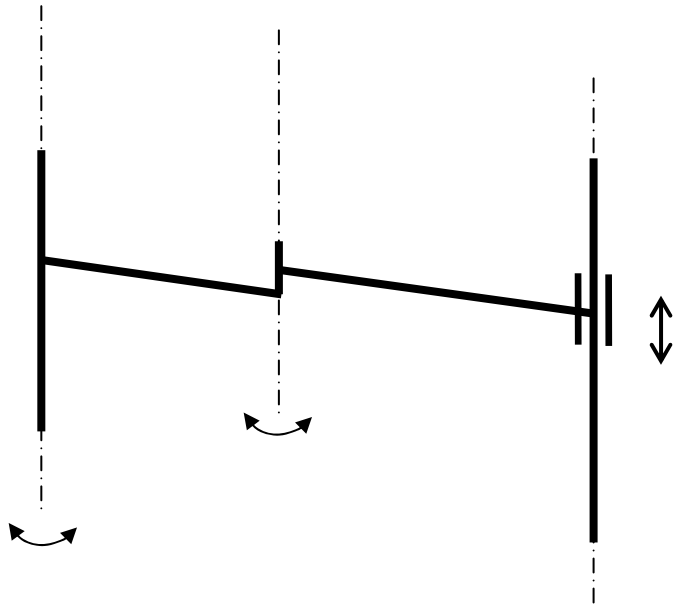
(iii) Suggest three additional features to improve the dishwasher:
(Any **three** of the following:)

- Automatic detergent dispenser
- Hot air blower
- UV light for sterilizing
- Remote control

(1 × 3) 3 (15)

Question 3 (Cont'd)

(b) (i) Sketch a line diagram of a 4-axis SCARA robot and illustrate the motion of the axes.



(1 × 4) 4

(ii) Two advantages of a SCARA robot:
(Any **two** of the following:)

- good for pick-and-place assembly work
- provides movements close to human arms
- with high speed and precision movements

(1 × 2) 2

(iii) Suggest one suitable gripper for assembling glass plates in production lines:
- vacuum rubber pad is commonly used for assembling glass plates in production lines 2 (8)

(c) Advantage of applying robot in each of the followings:

(i) Medical surgery:
(Any **one** of the following:)

- precision, smaller incisions
- decreased blood loss, less pain, and quicker healing time 1

(ii) Military use:
(Any **one** of the following:)

- Operating on their own under awkward and dangerous conditions
- Remotely operated from a command center

1 (2)

25 marks

END OF PAPER 2A

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PRACTICE PAPER

設計與應用科技　　試卷二乙
創意數碼媒體
DESIGN AND APPLIED TECHNOLOGY　PAPER 2B
CREATIVE DIGITAL MEDIA

評卷參考
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Question 4

(a) Design and sketch a storyboard of a 30-second video (not more than 6 frames) for a digital camera specifically designed for the elderly.

- Content of 'simple operation' and 'good quality' 5
- Notes on: annotation, audio-visual effect, speech & camera angles, etc. 5
- Sequencing 3
- Creativity & graphical presentation 7 (20)

(b) Design a slogan of not more than 18 words to promote the digital camera.

- Appropriate content & creativity 3
- Suitability of wordings 2 (5)

25 marks

Question 5 **Marks**

(a) Design and sketch any three of the following icons:

(i) Telephone
- Creativity and aesthetics 5
- Colour / line techniques 2

(ii) e-mail
- Creativity and aesthetics 5
- Colour / line techniques 2

(iii) Fax
- Creativity and aesthetics 5
- Colour / line techniques 2 (21)

OR

(iv) Address
- Creativity and aesthetics
- Colour / line techniques

(b) Any four factors that should be considered when the icons are to be used in printed format:
- converted to CMYK colour values
- appropriate image size
- resolution (dpi)
- appropriate file formats (such as '.pdf', '.ai')
- trim mark
- file / image compression
- paper stock

(1x4) 4

25 marks

Question 6

(a) Four design considerations when designing a pop-up card:

- theme of the card
- materials available
- structure of the pop-up action
- the size and shape

(1x4) 4

(b) Two suitable materials for making pop-up cards:
(Any two of the following:)

- fancy paper
- thin plastic sheet/ PVC sheet
- thin cardboard

(1x2) 2

(c) Sketches to illustrate the pop-up process(es) for the structure of the card:

- pop-up structure 7
- creativity, feasibility and matching with the theme 5
- presentation 3 (15)

(d) Two advantages of e-card:
(Any two of the following:)

- cost effectiveness in the sense of distribution of the message
- scope of reach is comparatively wider
- fast mobility (1x2) 2

Two disadvantages of e-card:

- lack of personal touch
- no tactile feeling (1x2) 2 (4)

25 marks

END OF PAPER 2B

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實踐設計及材料處理
DESIGN AND APPLIED TECHNOLOGY　PAPER 2C
DESIGN IMPLEMENTATION AND MATERIAL PROCESSING

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Question 7 **ks**

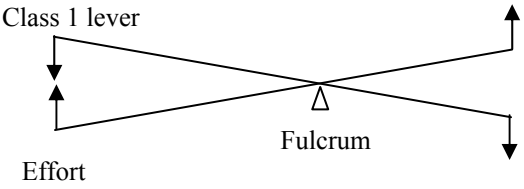
(a) Name the type of mechanism involved in each cutting tool shown in Figure 7:

- Flower cutter - Levers
- Nail clipper - linkage

Names
1 x 2

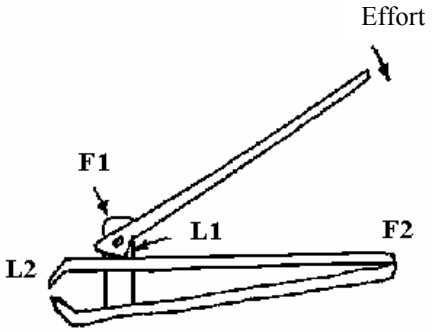
(b) Using a schematic diagram, illustrate the working principle of the mechanism applied in each of the cutting tools:

Flower cutter – Class 1 lever



Name 1
Notes 1
Sketches 3

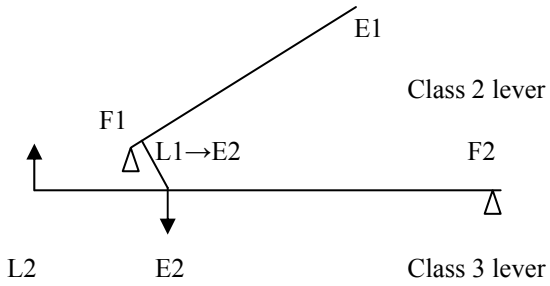
Nail cutter – Linkage



Load(L1) changes to effort(E2)

Name 1
Notes 1
Sketches 3

10

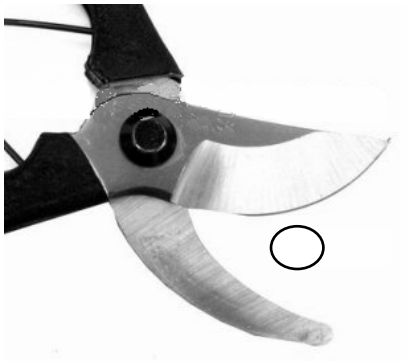


The linkage is composed of Class 2 lever and Class 3 lever

(c) Using notes and sketches,

(i) illustrate and explain one design feature of the cutting edge for each of the tools shown above:

- Flower cutter – the curved edge of the cutter helps to keep the flower branch in place while cutting.

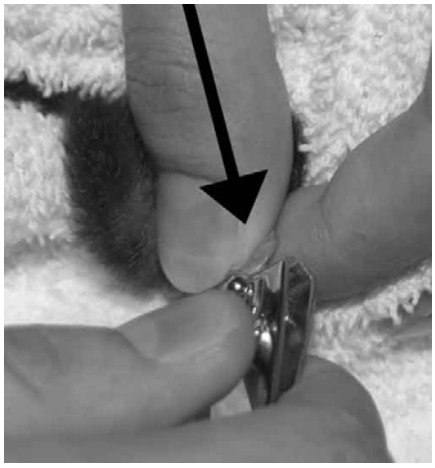


Notes 1
Sketches 2

6

Question 7 (Cont'd) **ks**

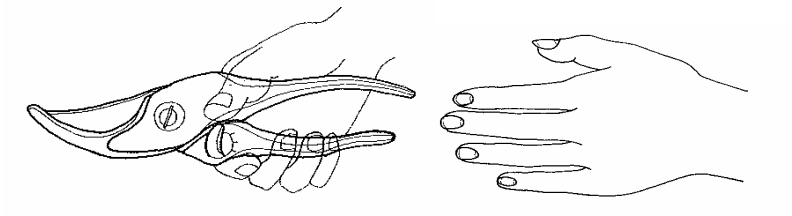
- Nail clipper – the curved edge of the clipper matches the curved shape of a human nail, so it cuts nails with ease.



Notes 1
Sketches 2

(ii) illustrate two ergonomic considerations which should be considered when designing one of the above cutting tools:

- Comfortable to use – the size shape, the material of the handle
- Fits the size of a hand



Notes 2
Sketches 2

7

- Comfortable to use - the size, shape, the material of the handle
- Fits the thumb

Notes 1
Sketches 2

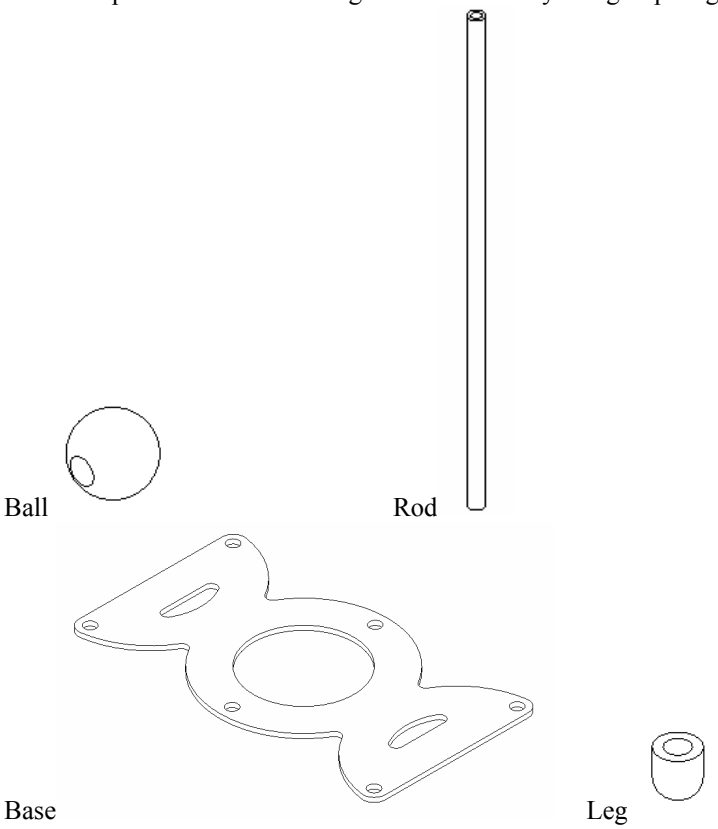
25 marks

Question 8 **ks**

(a) Using notes and sketches, illustrate how you would make the rack shown in Figure 8 in your school workshop. Your answer should include the materials and joints used.

- The rack will be composed of four parts, namely ball, rod, base and leg.

  - Standard wooden ball bought from the market and a hole is drilled for the rod;
  - The rod is made of PVC tube and cut to required length;
  - The base is made of acrylic sheet and cut by a laser cutter to required shape;
  - The leg is made of a wooden rod and cut to the required size. A hole is drilled for the rod and finally the bottom of the leg is sanded to an hemispherical shape;
  - All parts are assembled together and fixed by using impact glue.



Notes 4
Sketch 6

10

(b) In terms of mass production, suggest a suitable material for making the rack. Give two reasons for your choice.

Name 1
Reasons 2

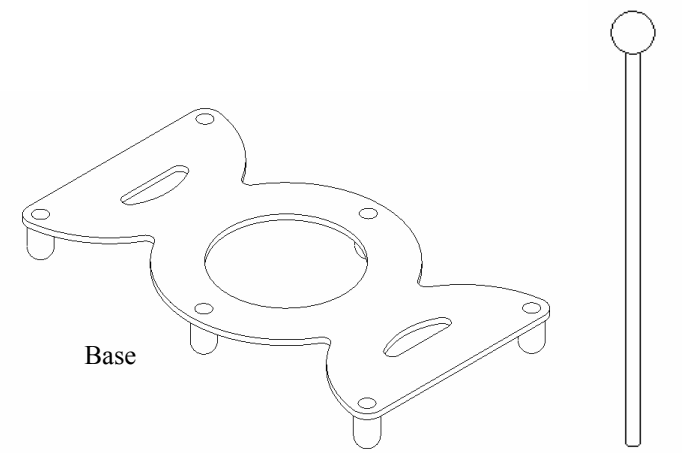
3

Acrylonitrile-Butadiene-Styrene (ABS)
Thermoplastics – good for injection moulding, low cost, hard and rigid

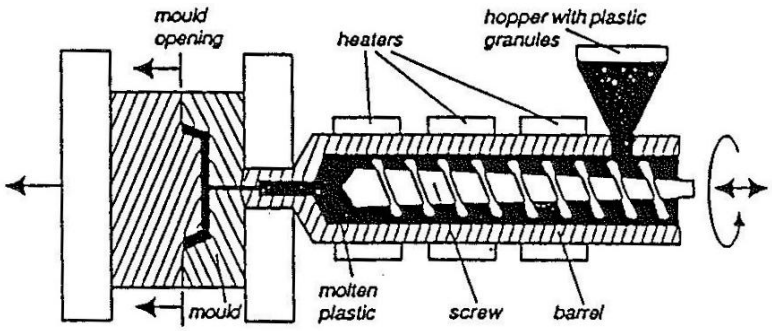
Question 8 (Cont'd) **...ks**

(c) Using notes and sketches, illustrate the mass production processes for making various parts of the rack.

- The rack is divided into two parts as below;



- Injection moulding
  This production method is mainly used for moulding thermoplastics.



12

Name 1
Sketches 6

Working process of Injection Moulding:

- The injection moulding machine consists of an injection unit and a mould;
- The plastic material is powder or granule form is held in a hopper where it is fed by a screw into the heated area of the machine where it becomes molten;
- The molten plastic is then forced under pressure through a nozzle into the mould which is made of two parts.
- The mould is filled and the molten plastic is allowed to cool;
- The mould is opened and the product is removed;
- The mould is then closed and the process repeated.

Notes 5

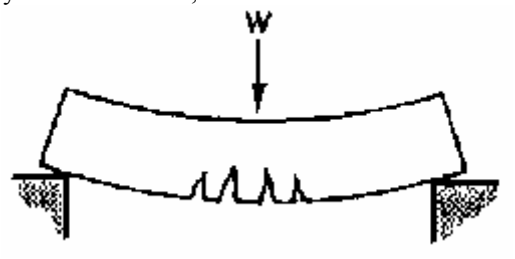
25 marks

Question 9 **ks**

(a) Using notes and sketches,

(i) illustrate the weakness of a pure concrete beam:

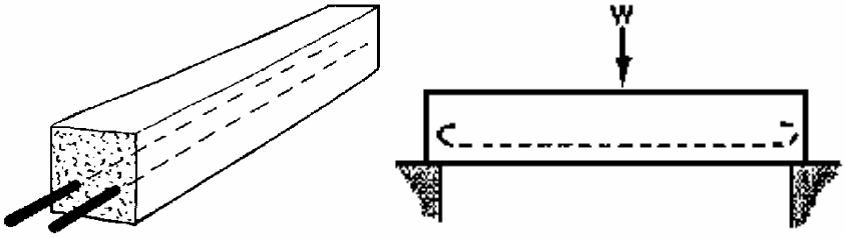
- When a beam is under load, the bottom edge of the beam is in tension. Since concrete is very weak in tension, it will crack.



Notes 1
Sketch 2 — 3

(ii) show how you would overcome this weakness:

- By adding steel rods at the bottom of beam, the tensile strength is increased so as to prevent the beam from cracking.



Notes 1
Sketches 2 — 3

(b) (i) If ' j' is the number of joints, 'b' is the required number of bars. Using the formula: $b = 2j - 3$,
calculate the number of bars required in Figure 9(b) to make the frame rigid.

- Applying formula:

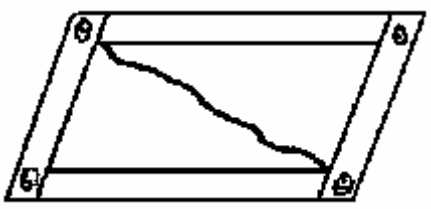
$b = 2j - 3$
$= 2(4) - 3$
$= 5$

- The number of bars required is 5.

Calculation 2
Answer 1 — 3

(ii) Using notes and sketches, explain why the wire used in Figure 9(c) would not make the frame rigid.

- Since the wire can only withstand tensile strength, the structure will distort as follows.

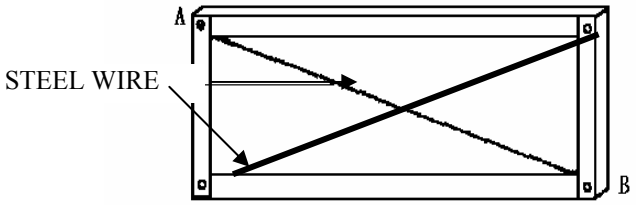


Notes 2
Sketches 2 — 4

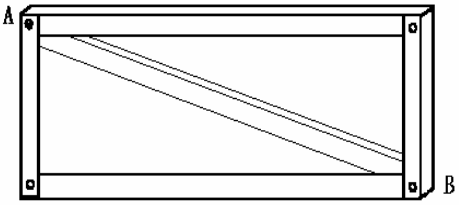
Question 9 (Cont'd) **ks**

(iii) Using notes and sketches, suggest two methods to make the frame in Figure 9(c) more rigid.

- Method 1: Add another steel wire as shown below.



- Method 2: Replace the wire with a steel rod as shown below.



Notes 1 x 2
Sketches 2 x 2

6

(c) (i) Using notes and sketches, identify the stronger beam in Figure 9(d) while it is under load. Give two reasons for your choice.

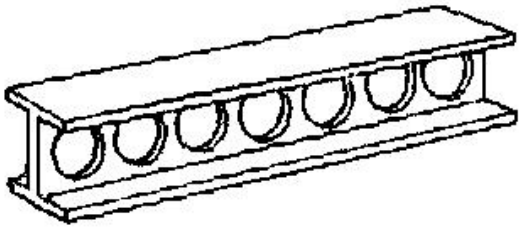
- I-beam provides a large moment of inertia and makes the beam stronger.
- Load acts at the middle of the I-beam which provides stronger support, while the square beam is hollow at the middle.

Name 1
Reasons 2

3

(ii) Illustrate one method to improve the performance of one of the beams shown in Figure 9(d).

- Force acting on a neutral axis is about zero, so drilling holes along the neutral axis can reduce weight without affecting the strength of the beam under bending and the lighter beam gives a better strength to weight ratio.



Notes 1
Sketch 2

3

25 marks

END OF PAPER 2C

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香港中學文憑考試
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION

練習卷
PRACTICE PAPER

設計與應用科技　　試卷二丁
電子
DESIGN AND APPLIED TECHNOLOGY　　PAPER 2D
ELECTRONICS

評卷參考
MARKING SCHEME

（2012年2月29日修訂稿）
(updated as at 29 Feb 2012)

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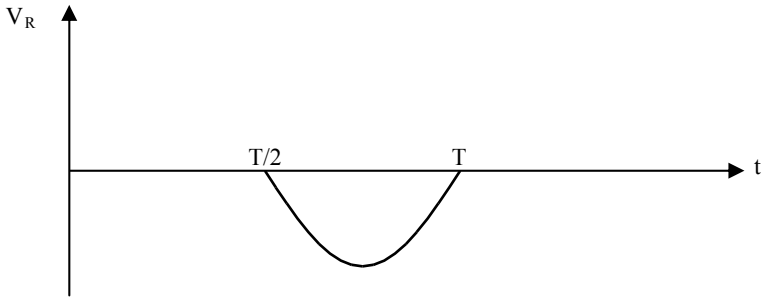
Question 10

(a) (i) Transformer. It steps down the high voltage from the primary winding to lower voltage at the secondary winding.

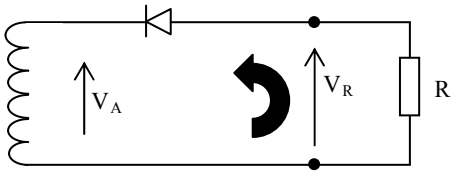
(ii) B is a diode/ rectifier
It conducts at one direction only. 2

(iii) The corresponding waveform of the voltage V_R across the resistor:



2

(iv) The current flow for each of the negative half - cycle of V_A:



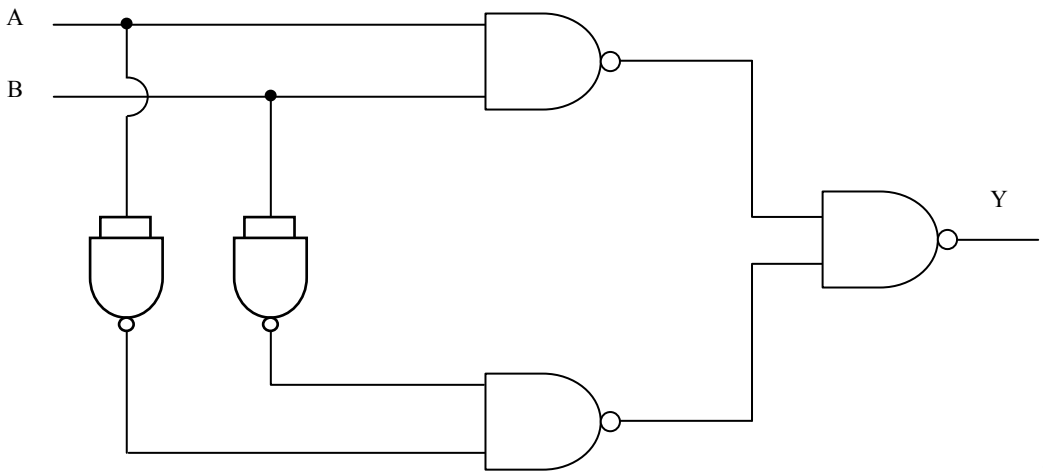
2 (8)

Question 10 (Cont'd)

(b) (i) The Boolean expression of Y is

$$Y = A \cdot B + \overline{A} \cdot \overline{B}$$

(ii) Using NAND gates only, sketch the circuit for the logic function:



6 (9)

(c) (i) Total circuit resistance

$= R_1 + (R_3 // R_4 // R_5) + R_2$

$= 1 + (10 // 8 // 4) + 2 = 1 + 2.1053 + 2 = 5.1035\Omega$

3

(ii) Total circuit current

$$= \frac{10\,V}{5.1053\,\Omega} = 1.9588\,A$$

Voltage across $R_4 = (1.9588\,A)(2.1053\,\Omega)$

$= 4.1238V$

Current flow through $R_4 = \frac{V}{R_4} = \frac{4.1238V}{8\Omega} = 0.5155A$

3

(iii) Total power dissipation of the circuit

= Power supplied from the source

= (10V)(1.9588A)

= 19.588W

2 (8)

25 marks

Question 11 **ks**

(a) Four characteristics of an ideal Op-Amp
- Infinite voltage gain
- Zero output resistance
- Infinite input resistance
- Infinite frequency bandwidth (1×4) 4

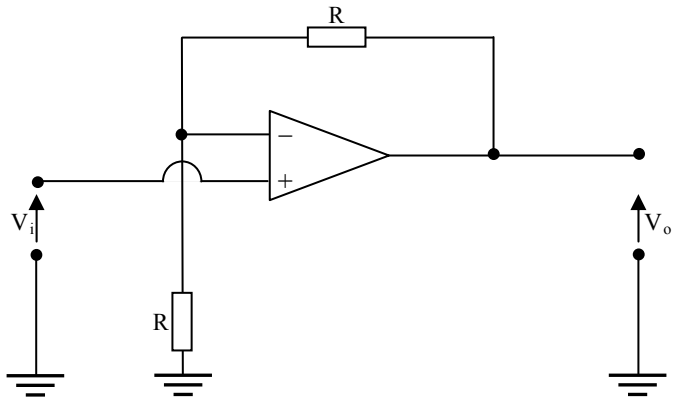
(b) (i) Two functions of Op-Amp:
- As a voltage comparator for the voltages at its +ve and –ve inputs
- It is used to drive the transistor (1×2) 2

(ii) Function of Q: Q function as an electronic switch 1
Reason: It is needed because the output current of Op-Amp is not sufficient to drive the dc alarm. 1

(iii) Describe briefly the purpose of VR.
VR is a variable resistor. By adjusting VR, the voltage at the –ve input of Op-Amp can be changed. Thus the threshold of the light intensity to trigger the alarm can be set. 2

(iv) Light from the LED is blocked from reaching the LDR. 2 (8)

(c) Draw the voltage amplifier circuit:



3

(d) (i)

Input Combinations	Output States
A=0 ; B=0	C=1 ; D=1
A=1 ; B=0	C=0 ; D=1
A=0 ; B=1	C=1 ; D=0
A=1 ; B=1	Same as the previous state. < No Change>

4

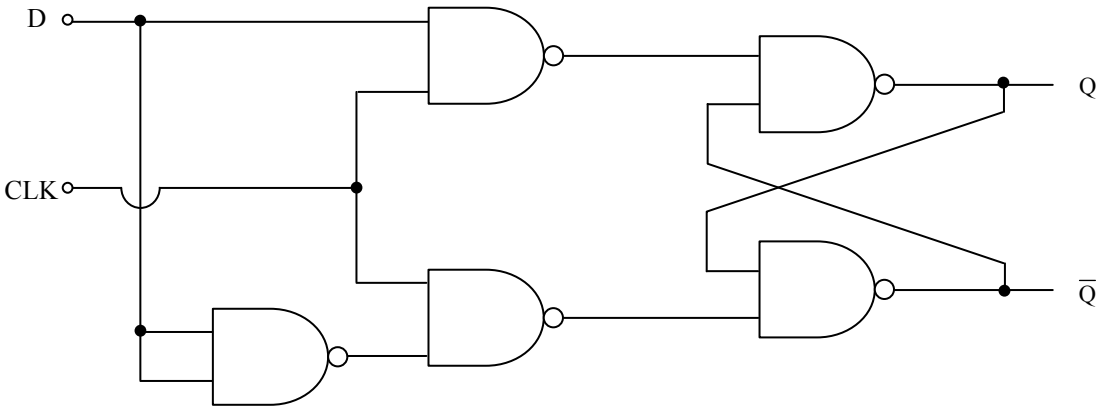
Question 11 (Cont'd) **Marks**

(ii) Sketch the truth table of a D- type flip flop:

D	Q	$\overline{Q}$
0	0	1
1	1	0

2

(iii) By adding extra NAND gates to the circuit, construct a D-type flip flop:



4

25 marks

Question 12 **Marks**

(a) (i) ROM – Read Only Memory
RAM – Random Access Memory

(ii) For ROM – it is a non-volatile memory, the data stored cannot be modified 1
For RAM – it is a volatile memory, the data will be lost if the power is switched OFF 1

(iii) Two uses of ROM:
ROM is used for permanent programs and storage of constant data 2

(iv) Two uses of RAM:
RAM is used as space for executing dynamically downloaded application programs and data which may be modified during execution 2 (8)

(b) (i) Two advantages of using 'Surface Mount Packages' in electronic products:
- It makes the smaller size of the devices and helps to reduce the physical size of the electronic product
- Components can be attached on both sides of PCB 2

(ii) Two difficulties of using 'Surface Mount Packages' in learning and experimental situations:
- Difficult to repair defective circuit boards using surface mount packages
- Due to small size of Surface Mount Packages, special tools are required to solder Surface Mount Devices to PCB

2 (4)

(c) (i)

Conditions	Output of Detector 'A'	Output of Detector 'B'
No box at check point	Low	Low
Height of box within the limit	Low	High
Height of box exceeds the limit	High	High

1
1
1 (3)

(ii)

GREEN indicator	RED indicator	Output of P1.1	Output of P1.2
OFF	OFF	High	High
ON	OFF	Low	High
OFF	ON	High	Low

1
1
1 (3)

(iii) Program (Pseudo Code) to control the micro-controller system:

```
LOOP
        IF      (B = 0)
                P 1.1 = 1, P 1.2 = 1; END IF
        IF      (A = 0 & B = 1)
                P 1.1 = 0 , P 1.2 = 1; END IF
        IF      (A = 1 & B = 1)
                P 1.1 = 1 , P 1.2 = 0; END IF
END LOOP
```

- correct program flow (LOOP) 3
- correct detection of presence of box 2
- correct detection of the height of box 2 (7)

Alternative answer:

e.g.

```
LOOP
        IF    (Detector Output B = Low)
        Then    Output P 1.1 = HIGH
                Output P 1.2 = HIGH
        ELSE    IF (Detector Output A = HIGH)
                THEN    Output P 1.1 = High
                        Output P 1.2 = Low
                ELSE    Output P 1.1 = Low
                        Output P 1.2 = High
                END IF
        END IF
END LOOP
```

25 marks

END OF PAPER 2D

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香港中學文憑考試
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION

練習卷
PRACTICE PAPER

設計與應用科技　　試卷二戊
視像化及電腦輔助設計模塑
DESIGN AND APPLIED TECHNOLOGY　PAPER 2E
VISUALISATION AND CAD MODELLING

評卷參考
MARKING SCHEME

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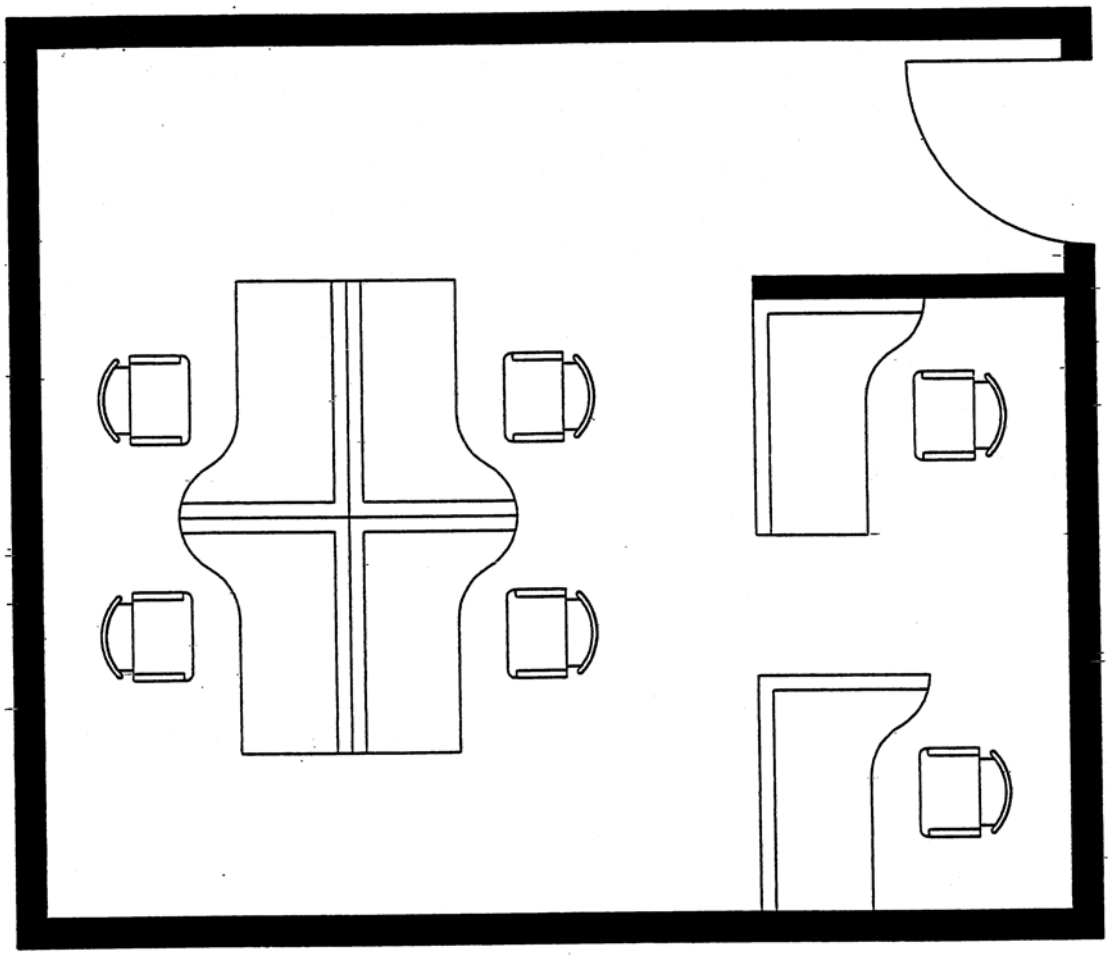
Question 13

(a) Draw six sets of desks and chairs on the office floor plan:

- Draw six sets of desks and chairs (2×6) 12
- Arrangement in good setting 2
- Draughtsmanship 1 (15)



Question 13 (Cont'd)

(b) Draw a coloured pie chart of the recycling materials:

List the percentage (angle) of each materials collected:
- wasted paper 33.3% (120^o) 3
- glass bottles 16.7% (60^o)
- aluminium cans 20.8% (75^o)
- tin cans 25% (90^o)
- plastic bottles 4.2% (15^o)

Draw the coloured 'pie chart' of the materials 5

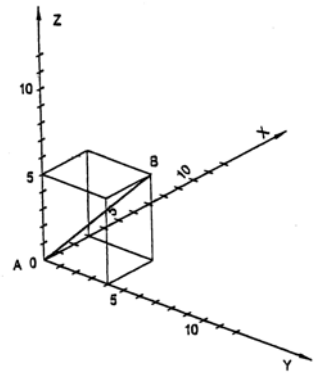
Colouring technique and draughtsmanship 2 (10)

Total: 25 marks

Question 14

(a) Using the 'Cartesian' method to illustrate the 3D spatial relationship between points A and B:

- From point A (0,0,0), draw (X,Y,Z) axes 1
- Mark off the coordinates of point B (3,4,5) 3
- Draw line AB 1 (5)



(b) Using 'Boolean operations', sketch and illustrate the major steps required in constructing the 3D CAD model:

- Rectangular block (100x60x88) - Rectangular block (100x35x60) 5
  $\Rightarrow$ L- shaped block
- L- shaped block - Cylinder 5
  $\Rightarrow$ L- shaped block with hole
- L- shaped block with hole - Rectangular block 5
  $\Rightarrow$ L- shaped block with hole/slot
- L- shaped block with hole/slot - 2 Wedge blocks 5 (20)
  $\Rightarrow$ The required 3D CAD model

Total: 25 marks

Question 15

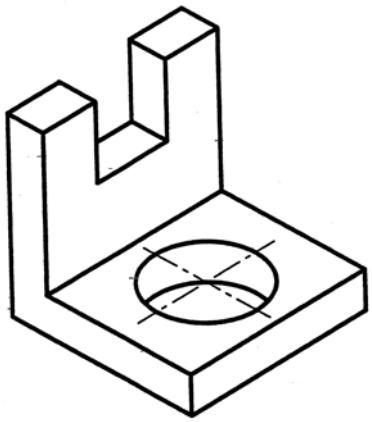
(a) Design and draw a coloured illustration to show that the water tap is controlled by an infra-red sensor:

- Creativity and aesthetics 6
- Colouring technique 4 (10)

(b) Draw the object after rotation:

- Correct orientation of the object 5
- The upper part of the object 3
- The lower part of the object 5
- Draughtsmanship 2 (15)

(Wrong scale – 3 marks)



Total: 25 marks

END OF PAPER 2E