



# Victorian Certificate of Education 2011

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

## STUDENT NUMBER

Figures

Words


Letter

--

# SYSTEMS ENGINEERING

## Written examination

Friday 18 November 2011

Reading time: 9.00 am to 9.15 am (15 minutes)

Writing time: 9.15 am to 10.45 am (1 hour 30 minutes)

## QUESTION AND ANSWER BOOK

### Structure of book

<i>Section</i>	<i>Number of questions</i>	<i>Number of questions to be answered</i>	<i>Number of marks</i>
A	20	20	20
B	33	33	65
			Total 85

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

#### Materials supplied

- Question and answer book of 24 pages including formulas on page 24.
- Answer sheet for multiple-choice questions.

#### Instructions

- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- All calculations must show appropriate formulas and working.
- All written responses must be in English.

#### At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.

**Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.**

**SECTION A – Multiple-choice questions****Instructions for Section A**

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** for the question.

A correct answer scores 1, an incorrect answer scores 0.

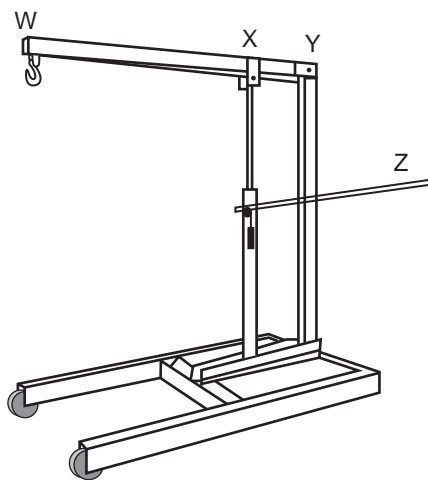
Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

A formula sheet is provided on page 24.

Unless indicated diagrams are not to scale.

Use the diagram of the hydraulic crane below to answer Questions 1 and 2.

**Question 1**

The class of lever used in the crane is

- A. first order.
- B. second order.
- C. third order.
- D. fourth order.

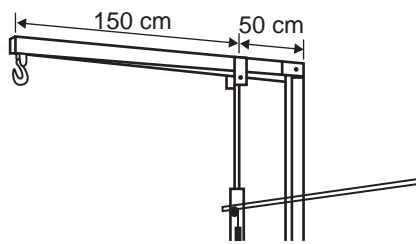
**Question 2**

At which set of points on the crane are the effort, fulcrum and load indicated?

	Effort	Fulcrum	Load
A.	Z	X	Y
B.	X	Y	Z
C.	Z	X	W
D.	X	Y	W

**Question 3**

Assume that the beam and the hydraulic cylinder are at right angles.

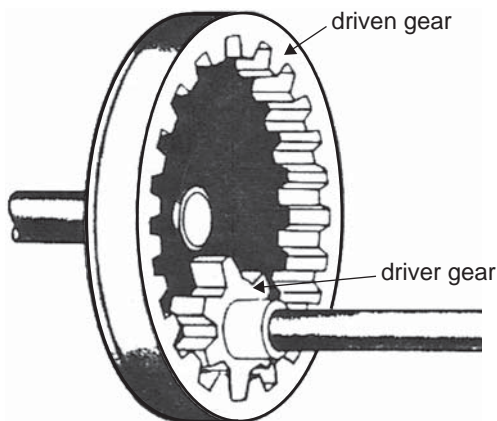


The mechanical advantage applied to the crane's beam by the hydraulic cylinder is

- A.  $\frac{1}{4}$
- B.  $\frac{1}{3}$
- C. 3
- D. 4

**Question 4**

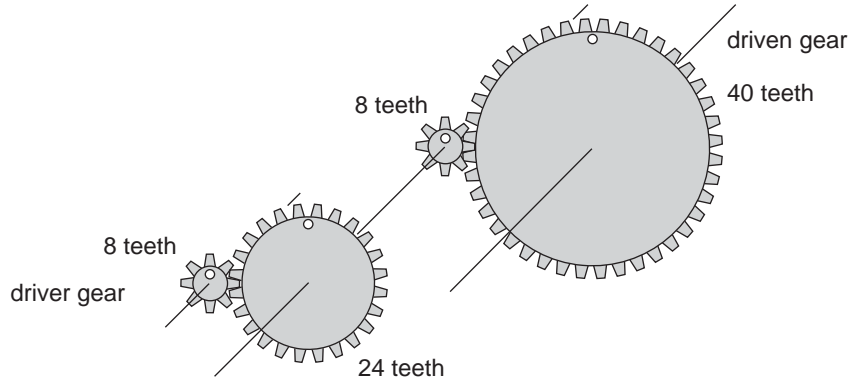
The driver gear in the diagram below has 8 teeth and turns clockwise. The driven gear has 22 teeth.



What is the gear ratio of the driven gear to the driver gear and direction of rotation of the driven gear?

- A. 4:11 anticlockwise
- B. 4:11 clockwise
- C. 11:4 anticlockwise
- D. 11:4 clockwise

**Question 5**

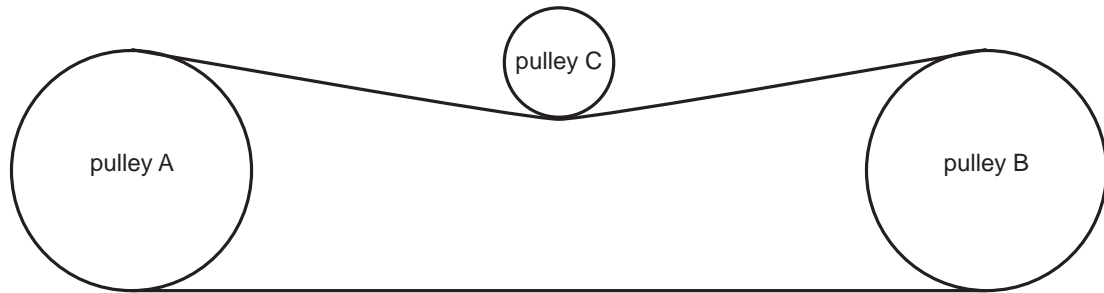


The gear ratio of the gear train above is

- A. 1:8
- B. 1:15
- C. 8:1
- D. 15:1

**Question 6**

Pulley A has a diameter of 100 mm and turns clockwise at 1000 rpm. Pulley B has a diameter of 100 mm. The tensioning pulley C has a diameter of 50 mm.



What is the rpm and direction of rotation of pulley C?

- A. 500 rpm clockwise
- B. 500 rpm anticlockwise
- C. 2000 rpm clockwise
- D. 2000 rpm anticlockwise

**Question 7**

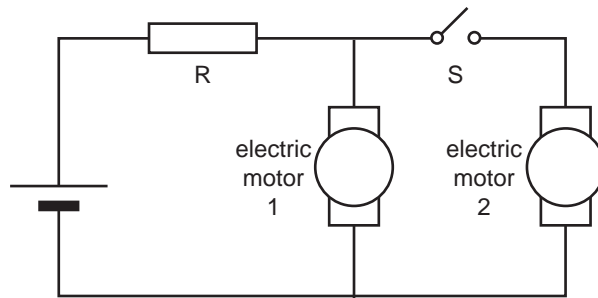
Which of the following are all maintenance processes?

- A. manufacturing, lubrication, testing, assembling
- B. adjustment, cleaning, lubrication, testing
- C. adjustment, lubrication, testing, constructing
- D. adjustment, cleaning, designing, assembling

**Question 8**

When preparing to use a chemical substance in a production work process, which source of information should be obtained and read first?

- A. Material Safety Data sheet
- B. Workplace instruction sheet
- C. Project planning guidelines
- D. Instructions on the label of the chemical substance

**Question 9**

If switch S in the circuit shown above is closed, the shaft of electric motor 1 will

- A. stop rotating.
- B. rotate at a faster speed.
- C. rotate at a slower speed.
- D. rotate at the same speed.

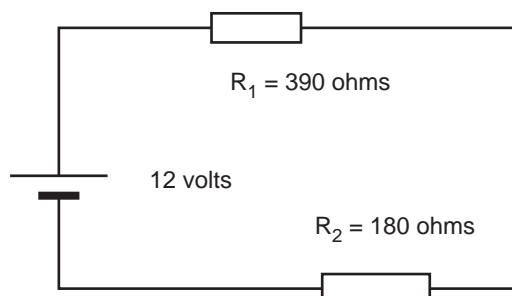
**Question 10**

A transducer is a device that transforms

- A. AC voltage to DC voltage.
- B. analogue signals to digital signals.
- C. one type of energy to another form.
- D. an N type semiconductor to a P type semiconductor.

**Question 11**

A 12 volt power source is connected to two resistors as shown in the circuit below.

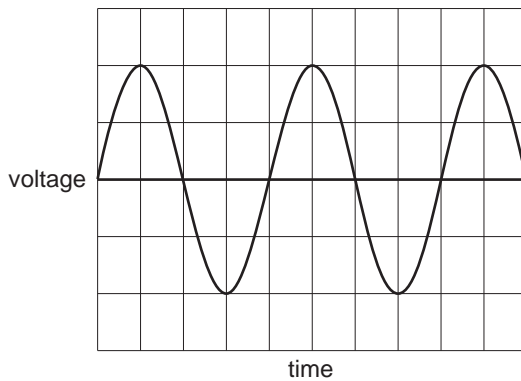


A voltmeter connected across  $R_1$  will read 12 volts if

- A.  $R_1$  is shorted with a connecting wire.
- B.  $R_2$  is shorted with a connecting wire.
- C. the battery connections are reversed.
- D. the connecting wire between  $R_1$  and  $R_2$  is cut.

Use the following information to answer Questions 12 and 13.

Below is the display of a cathode ray oscilloscope.

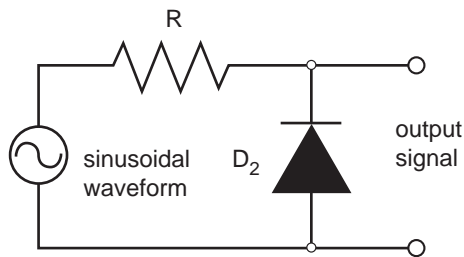


**Question 12**

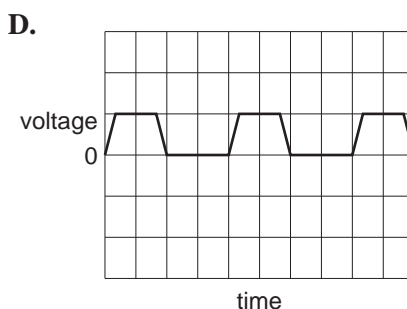
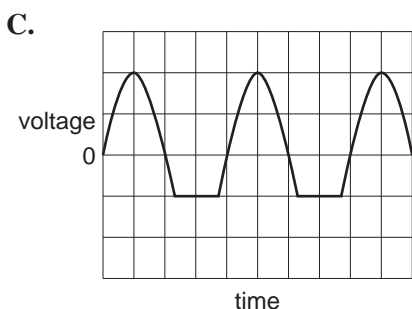
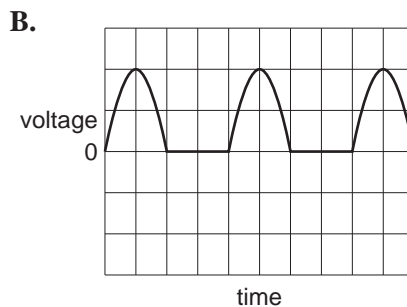
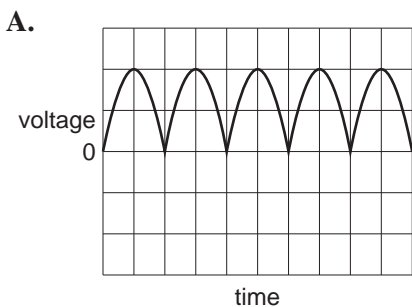
Given that the horizontal scale is 0.05 seconds per division and the vertical scale is 5 volts per division, the peak voltage and frequency of the above signal are

- A. 2 volts and 0.2 Hz.
- B. 10 volts and 2 Hz.
- C. 10 volts and 5 Hz.
- D. 2 volts and 10 Hz.

**Question 13**



Which one of the following shows the output signal across a diode, given the input signal from the cathode ray oscilloscope above?



**Question 14**

The table below shows the specifications for 5 mm green and 5 mm blue light-emitting diodes.

	Forward voltage	Current drawn
Green	2.1 volts	20 mA
Blue	3.5 volts	20 mA

The green light-emitting diode compared with the blue one

- A. has a lower resistance.
- B. has a higher resistance.
- C. consumes more power.
- D. consumes the same amount of power.

**Question 15**

The purpose of heat sink pliers is to

- A. hold small components when tightening fasteners.
- B. hold the circuit board safely when constructing an electrical circuit.
- C. assist in preventing dry solder joints when constructing an electrical circuit.
- D. absorb heat while soldering components when constructing an electrical circuit.

**Question 16**

Before using an electrically powered tool, for example an electric drill, the most important check to make is that the tool

- A. is double insulated.
- B. has a current electrical test tag.
- C. has been used safely in the past.
- D. is approved to the relevant Australian standard.

**Question 17**

A fuel cell is an electrochemical cell that

- A. can be recharged.
- B. is used in mobile phones.
- C. converts a fuel source into an electric current.
- D. provides higher voltage than standard cell batteries.

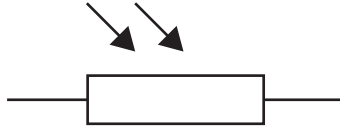
**Question 18**

Identify the major hazard which will occur if an undersized electrical cable is selected to connect a power supply to an operating circuit.

The electrical cable will

- A. break.
- B. overheat.
- C. short circuit.
- D. not have enough resistance.

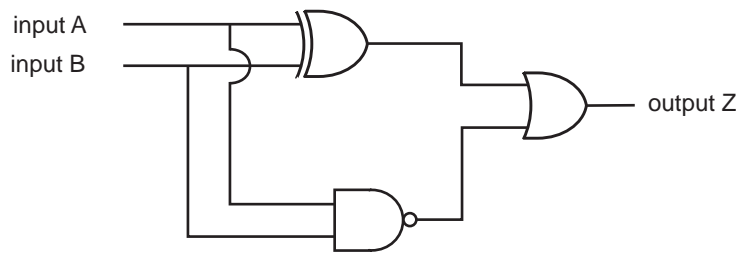
**Question 19**



The electronic symbol shown above is for

- A. a thermistor.
- B. an infrared receiver.
- C. a light-emitting diode.
- D. a light-dependent resistor.

**Question 20**



Which of the truth tables below represents the circuit above?

**A.**

A	B	Z
0	0	0
0	1	1
1	0	1
1	1	1

**B.**

A	B	Z
0	0	1
0	1	0
1	0	1
1	1	1

**C.**

A	B	Z
0	0	1
0	1	1
1	0	0
1	1	1

**D.**

A	B	Z
0	0	1
0	1	1
1	0	1
1	1	0



## SECTION B – Short answer questions

### Instructions for Section B

Answer **all** questions in the spaces provided.

A formula sheet is provided on page 24.

Unless indicated the diagrams are not to scale.

Use the following information to answer Questions 1–3.

Elevators are used to lift goods and people from one level to another. The earliest elevators were manually operated and used a drive system based on a hoist. A simple elevator is shown in Figure 1.

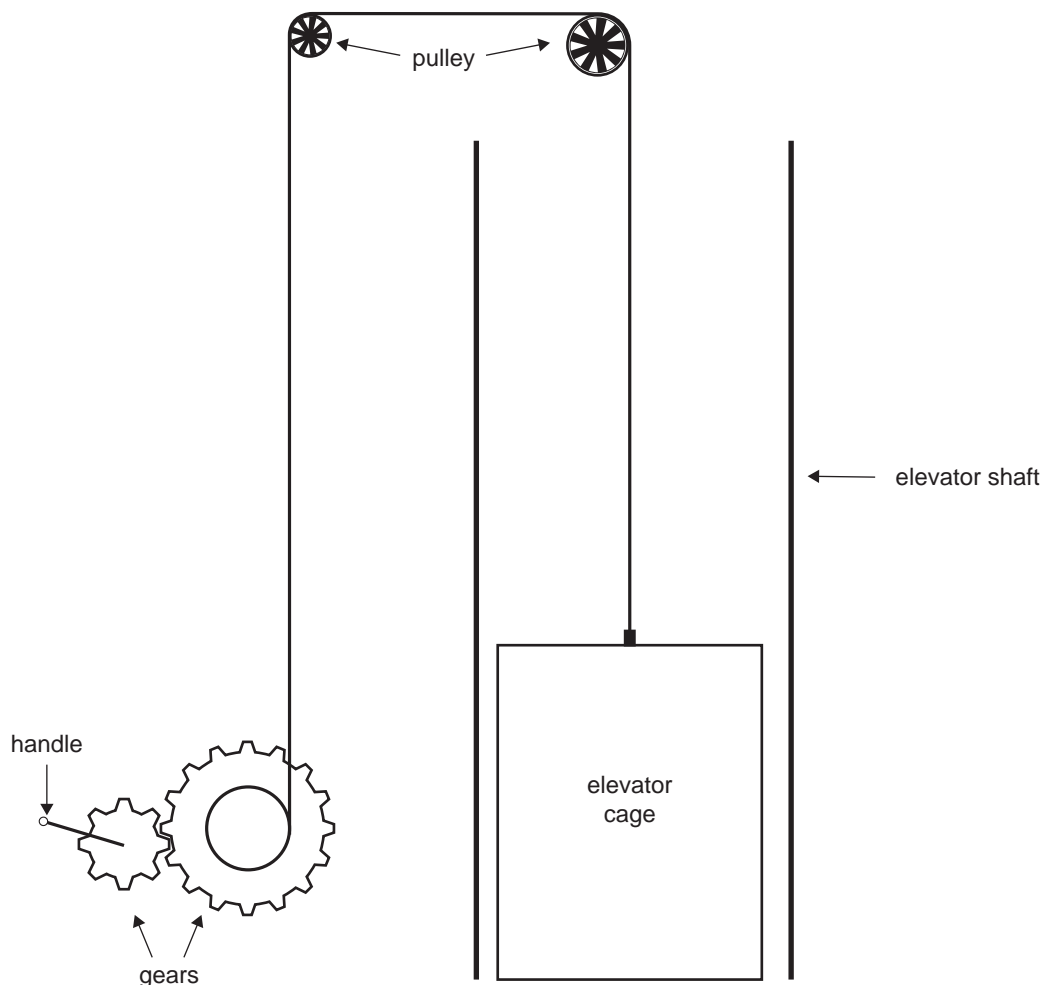


Figure 1

#### Question 1

Indicate with an arrow on the diagram in Figure 1 the direction the handle must turn for the elevator cage to go up.

1 mark

#### Question 2

Name the type of motion of the elevator as it is raised.

1 mark

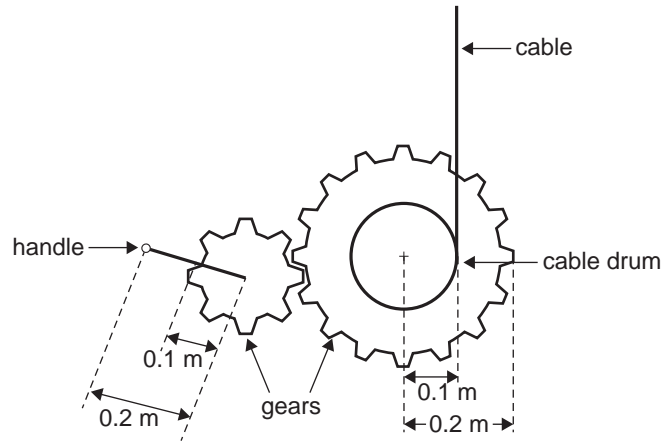
**Question 3**

Identify two forms of useful output energy in the hoist system that are present while the elevator is being raised.

1. \_\_\_\_\_
2. \_\_\_\_\_

2 marks

Use the following figure to answer Questions 4 and 5.



**Figure 2**

**Question 4**

If a force of 400 N is applied to the handle, calculate the maximum input torque.

Show working.

---



---

2 marks

**Question 5**

The handle is rotated at 24 rpm.

- a. Calculate the rpm of the cable drum.

Show working.

---



---

2 marks

- b. Calculate the distance moved by the elevator cable in one minute.

Show working and include units.

---



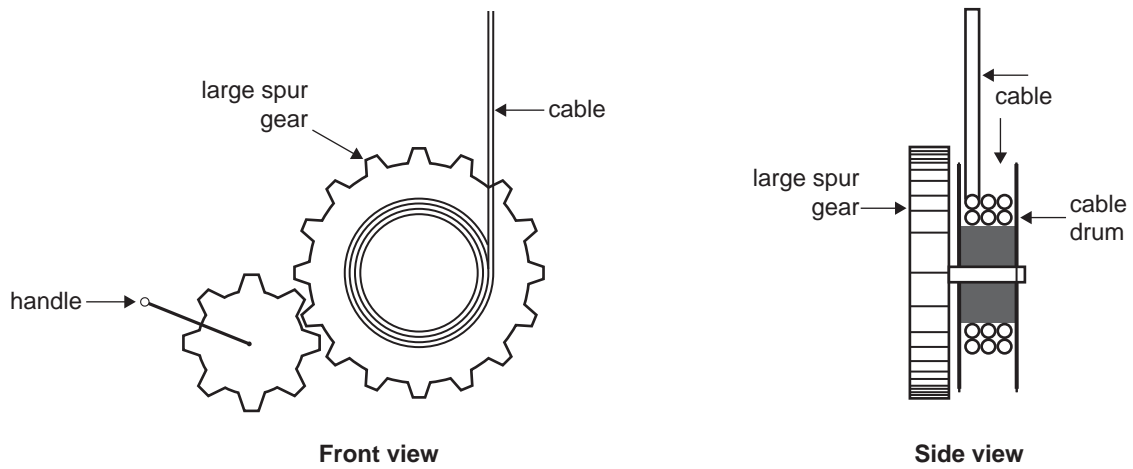
---

2 marks

**SECTION B** – continued

**Question 6**

While operating this mechanical system, the operators complained that the lifting effort required increased as the elevator was raised.

**Figure 3**

Did the operators have a valid complaint? Explain your answer.

---



---



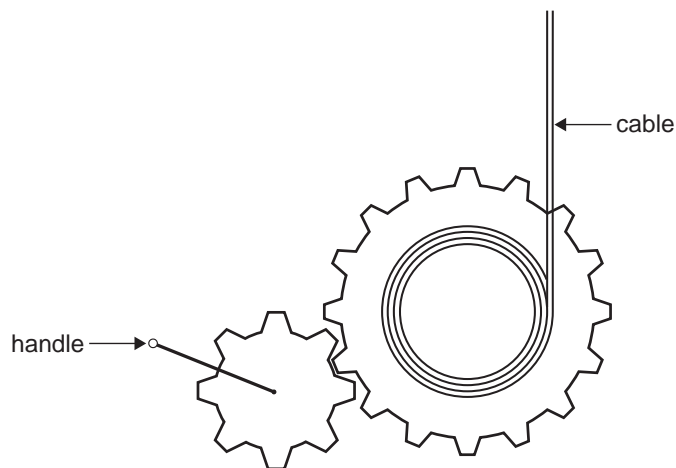
---

2 marks

**Question 7**

A pawl is used to hold the elevator in a raised position.

Draw and label a correctly positioned functional pawl on Figure 4 below.

**Figure 4**

2 marks

Use the following information to answer Questions 8 and 9.

As elevators developed over time, counterweights were introduced as shown in Figure 5 below.

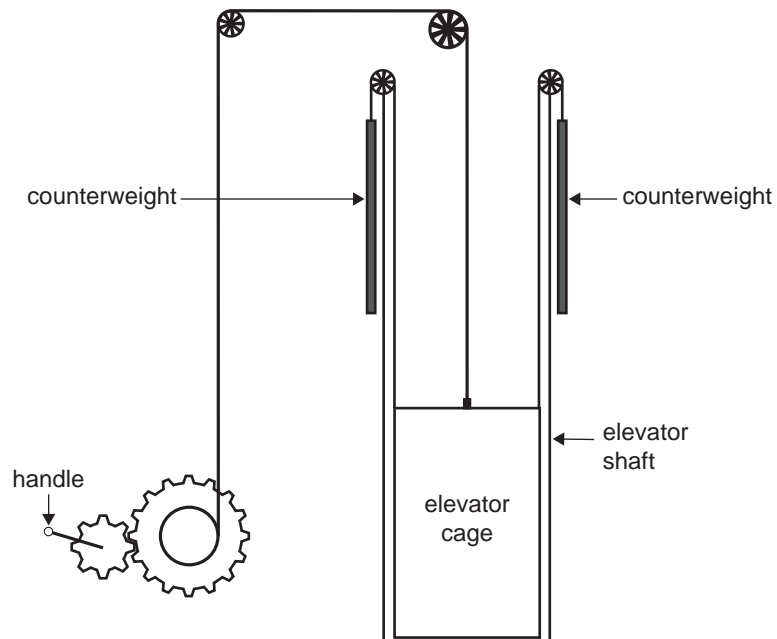


Figure 5

**Question 8**

What is the purpose of counterweights in the system?

---



---

1 mark

**Question 9**

What will happen if each of the two counterweights in Figure 5 has a mass of 600 kg and the mass of the elevator cage is 1000 kg?

---

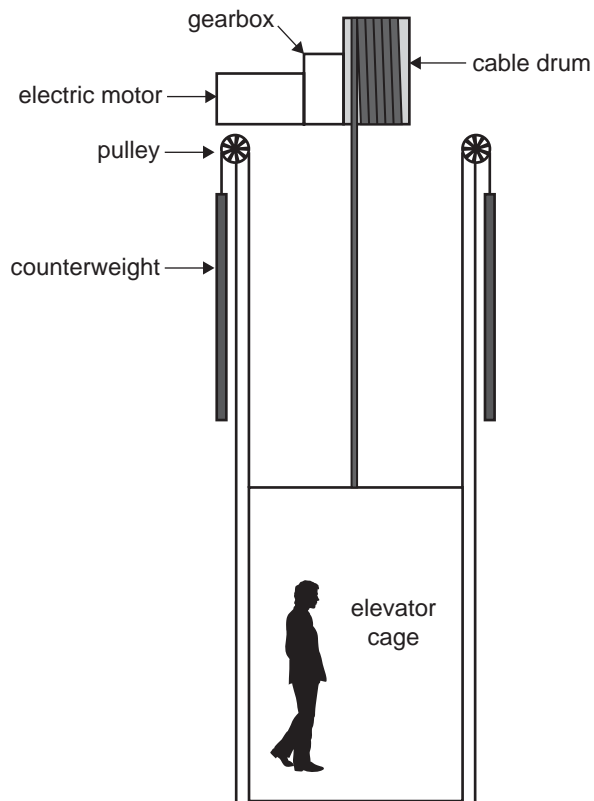


---

1 mark

Use the following information to answer Questions 10–12.

Modern elevators are driven by an electric motor connected to a gearbox driving the cable drum, as shown in Figure 6 below.



**Figure 6**

The motor is rated at 3 kW and has a supply voltage of 240 V.

**Question 10**

Calculate the maximum mechanical power available to raise the elevator if the motor is 85% efficient in converting electrical power to mechanical power.

Show working.

---



---



---

2 marks

**Question 11**

Calculate the current flow through the motor.

Show working.

---



---

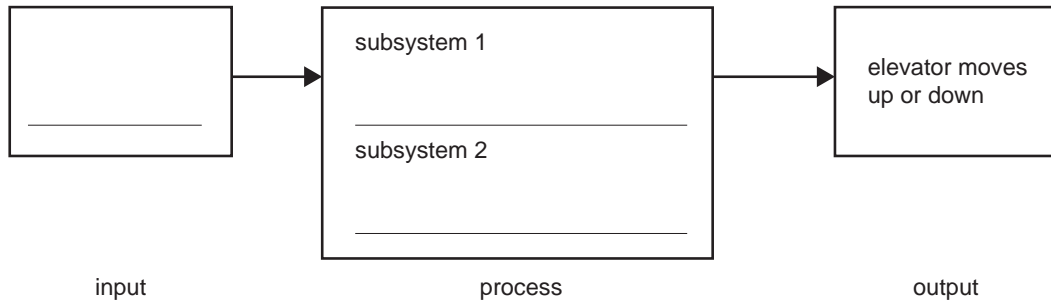


---

2 marks

**Question 12**

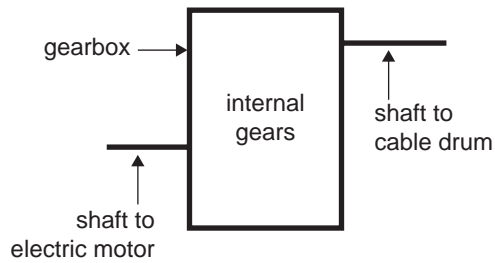
Identify the **input** and **two subsystems** that make the modern elevator (as in Figure 6 on page 13) an integrated system.



3 marks

**Question 13**

A diagram of the gearbox connecting the electric motor to the cable drum is shown in Figure 7 below.



**Figure 7**

Describe a diagnostic test that will allow you to determine the gear ratio of the gearbox.

---

---

---

---

2 marks

Use the following information to answer Questions 14 and 15.

Elisha Otis was the first person to patent a safety system for an elevator. Figure 8 below shows a simplified version of his patent.

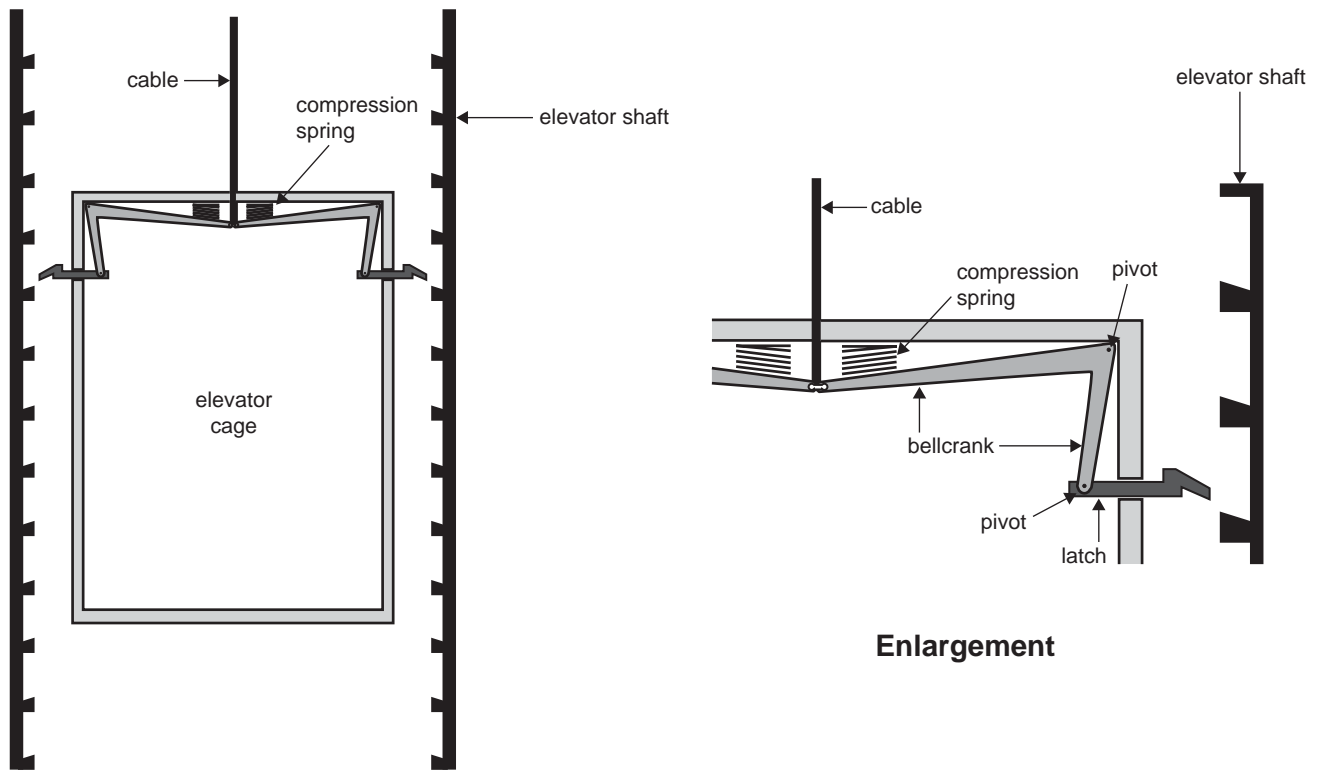


Figure 8

**Question 14**

Name the type of force in the cable.

---

1 mark

**Question 15**

Explain how the safety mechanism would operate if the cable broke.

---



---



---

2 marks

Use the following information to answer Questions 16 and 17.

Figure 9 shows how hydraulics can be used to operate an elevator.

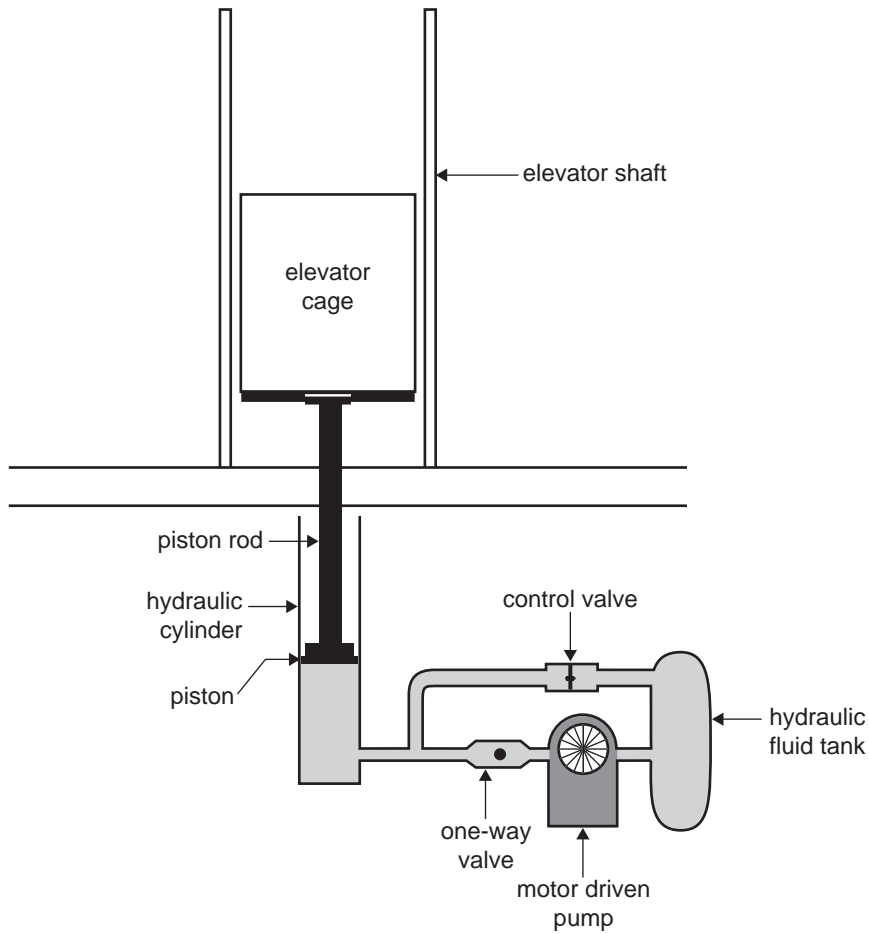


Figure 9

**Question 16**

The diameter of the hydraulic cylinder is 300 mm, the diameter of the piston rod is 100 mm and the pressure of the pump is 120 000 Pa.

Calculate the force applied to the piston. Show working and include units.

---



---



---

3 marks

**Question 17**

a. What is the purpose of the one-way valve?

---

1 mark

b. State the effect on the hydraulic circuit when the control valve is open.

---

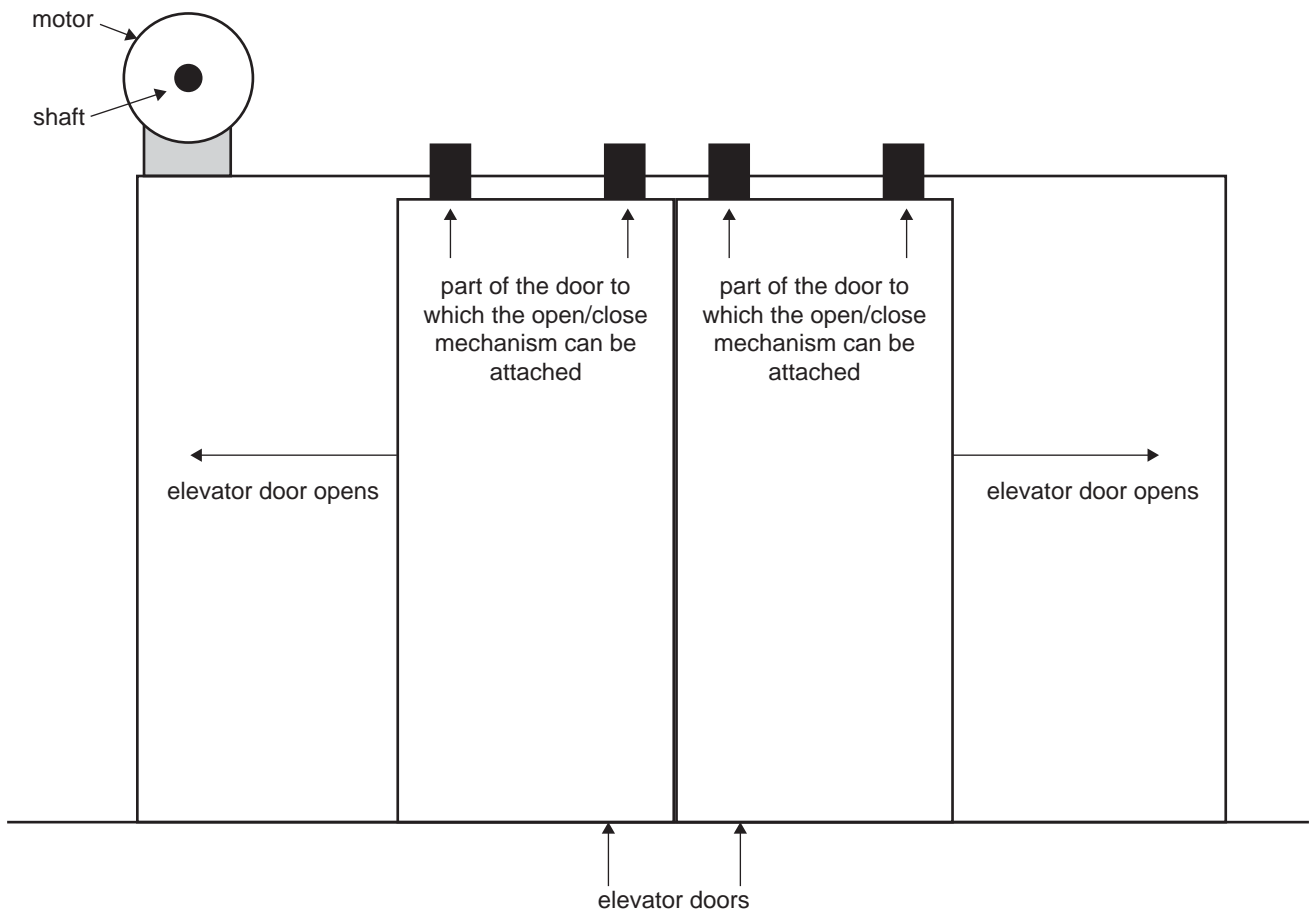
1 mark



**Question 18**

The doors of the elevator require an opening and closing mechanism.

- a. Design and sketch below a motorised opening and closing mechanism, using components such as gears, pulleys, racks, belts, metal tubes, hinges, and nuts and bolts as needed.



**Figure 10**

2 marks

- b. Describe how your opening and closing mechanism works.

---



---



---

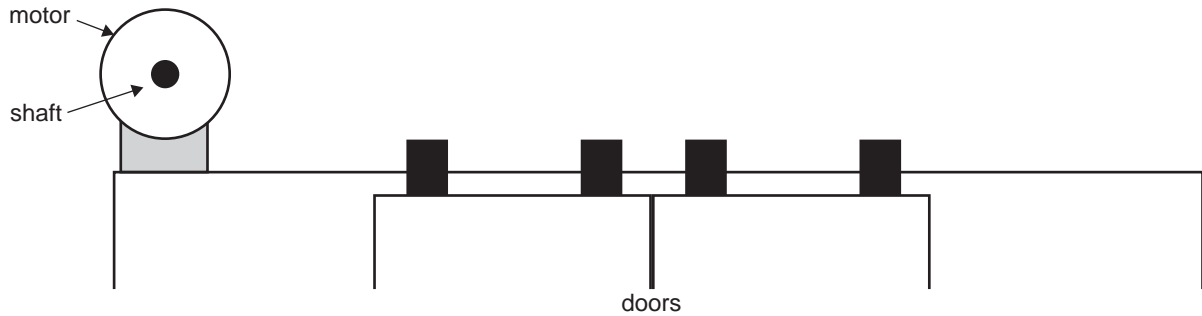


---

2 marks

**Question 19**

Both doors on the elevator must be closed before the elevator can go up or down.  
 Two contact switches are to be used to determine whether or not the doors are fully closed.  
 On the diagram below, mark where these switches could be placed.

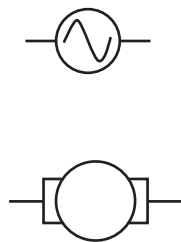


**Figure 11**

1 mark

**Question 20**

Complete the circuit diagram below so that the elevator can operate only when both switches are closed.



2 marks

**Question 21**

On the circuit you have completed in **Question 20**, draw a voltmeter to measure the input voltage of the circuit.  
 1 mark

**Question 22**

a. Name a different type of electrical component that could be used instead of a contact switch.

\_\_\_\_\_ 1 mark

b. Explain the operation of this electrical component.

\_\_\_\_\_  
 \_\_\_\_\_ 1 mark

Use the following information to answer Questions 23 and 24.

Figure 12 is a block circuit diagram for the operation and control of the elevator.

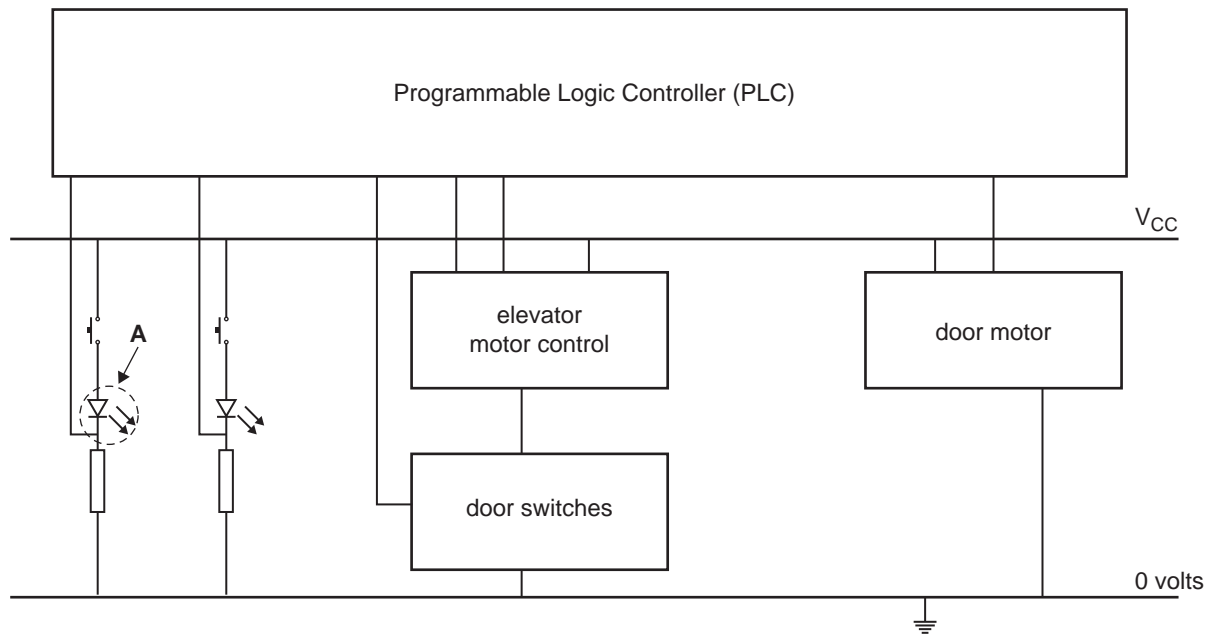


Figure 12

### Question 23

- a. What is the name of component A?

\_\_\_\_\_ 1 mark

- b. What is the purpose of this component?

\_\_\_\_\_ 1 mark

### Question 24

Identify one device that controls input and one device that provides output of the elevator control circuit.

input \_\_\_\_\_ output \_\_\_\_\_

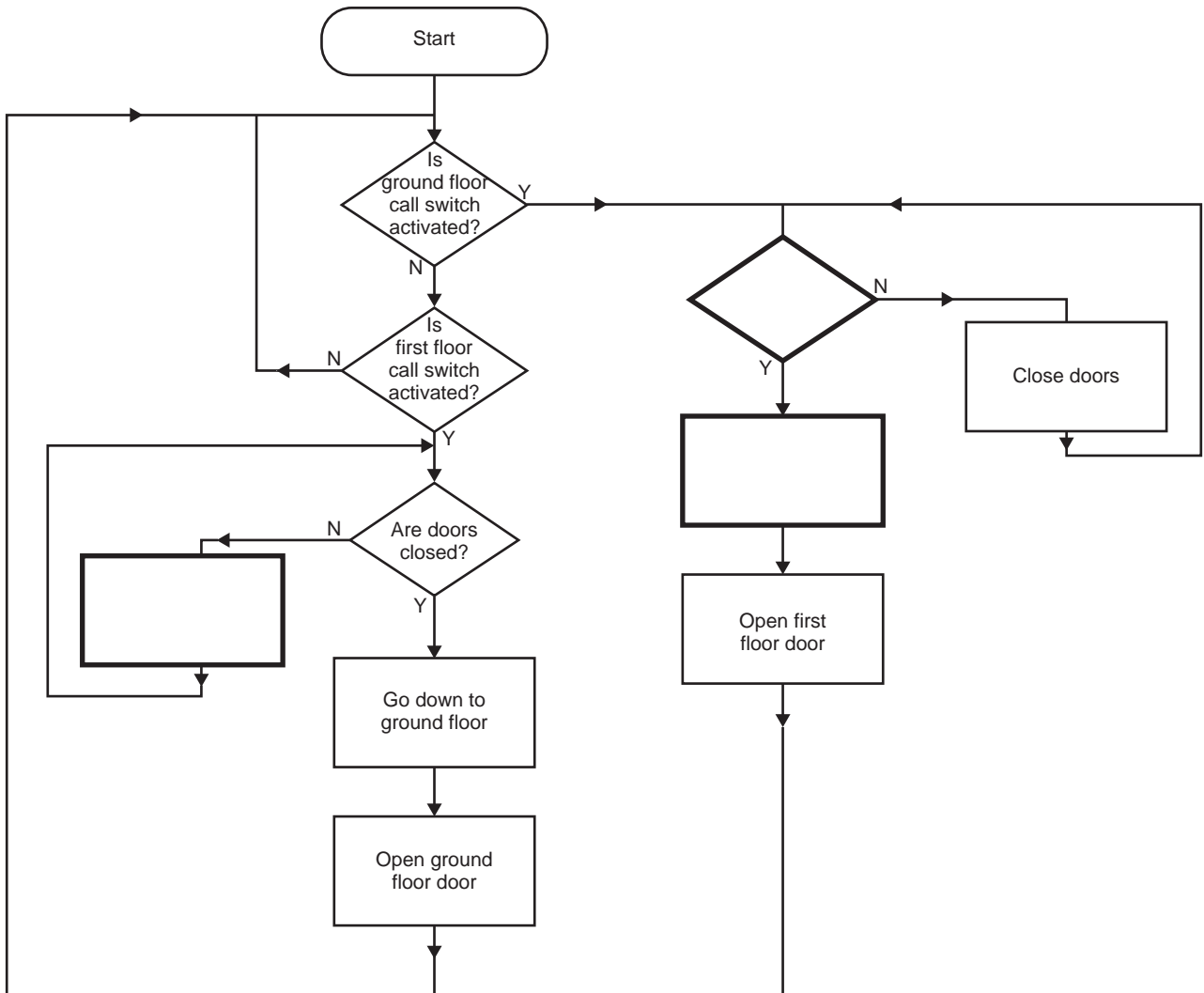
2 marks

**Question 25**

Complete the flow chart by allocating the processes in the correct order for the elevator cage to operate up or down in a two-storey building.

To complete the flow chart, place the **number of** each process in the appropriate place.

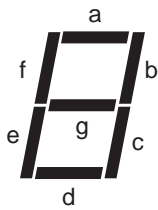
1. Close doors.
2. Go up to first floor.
3. Are doors closed?



1 mark

**Question 26**

In buildings with more floors, a seven segment display is used to show on which level the elevator is located.



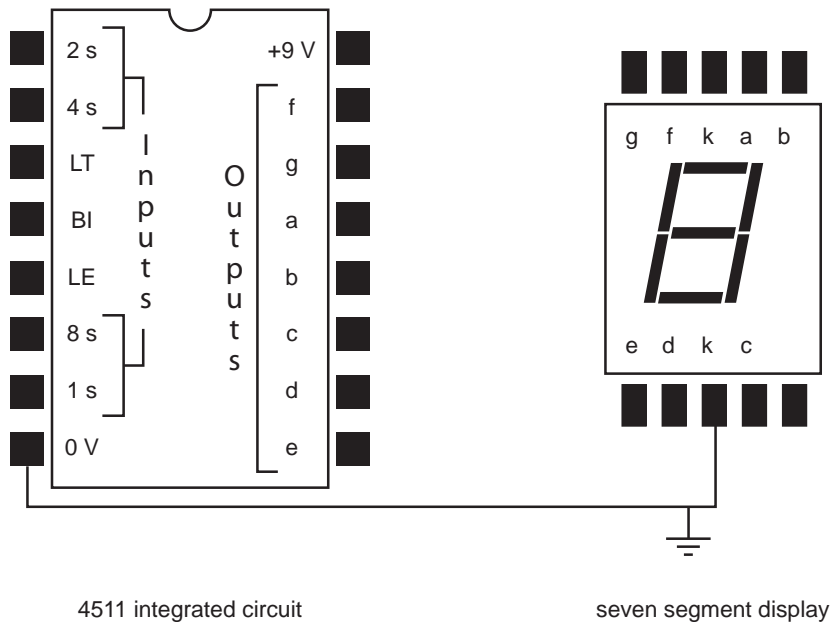
Give the letters of the segments that would light up to give the number 7.

---

1 mark

**Question 27**

On Figure 13 below, draw the circuit board connections between the seven segment display and the 4511 integrated circuit. (The connection for the ground and 0 volt rail is shown.)



**Figure 13**

2 marks

Use the following information to answer Questions 28–30.

Figure 14 shows a circuit that could be used for giving a display of the floor number.

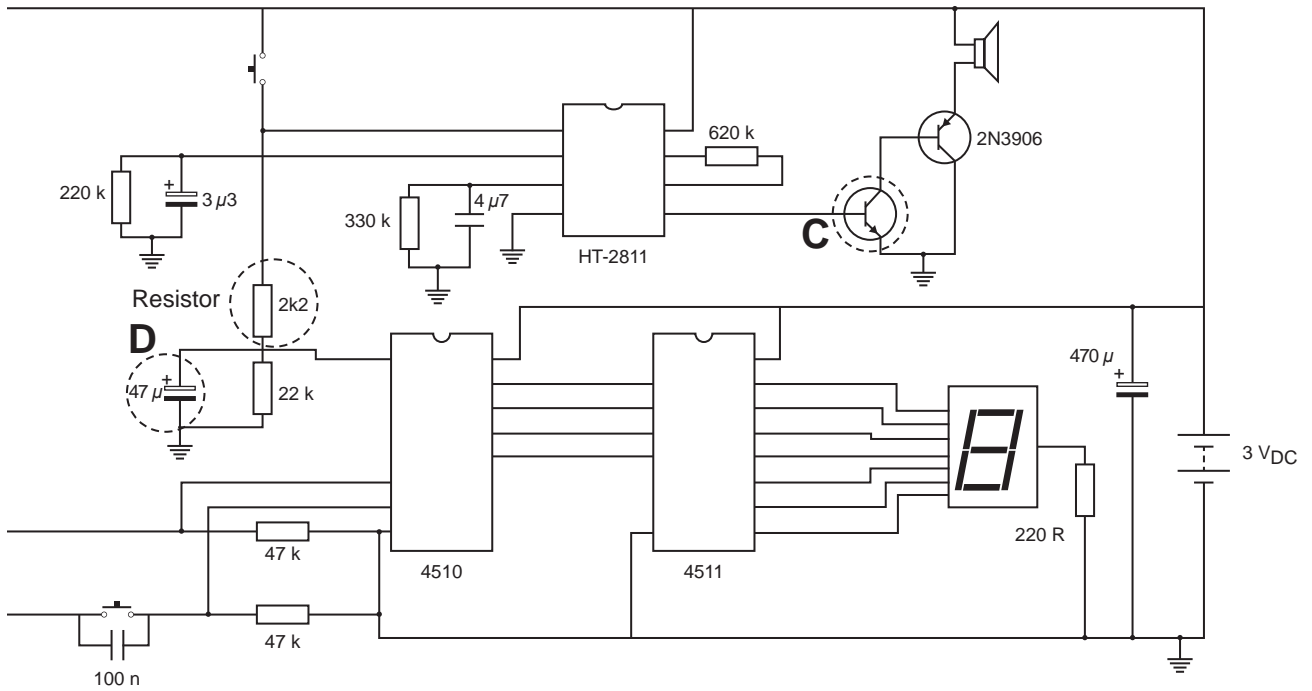


Figure 14

**Question 28**

a. State the name and type of component C.

\_\_\_\_\_ 2 marks

b. State two applications for this component.

1. \_\_\_\_\_

2. \_\_\_\_\_

2 marks

**Question 29**

a. State the name and type of component D.

\_\_\_\_\_ 2 marks

b. State one application for this component.

\_\_\_\_\_ 1 mark

**Question 30**

Give the colour code of the 2k2 resistor with a 5% tolerance.

\_\_\_\_\_ 1 mark

*Use the following information to answer Questions 31 and 32.*

The 2k2 resistor circled in Figure 14 is not available. Instead, the following resistors are available: 820 R, 1000 R, 1k2, 3k3, 4k7, 6k8.

**Question 31**

Using two resistors from the list above, draw and label a series circuit that can be used to replace the 2k2 resistor.

2 marks

**Question 32**

Using two resistors from the list above, draw and label a parallel circuit to give the closest possible value to 2k2.

2 marks

**Question 33**

The interior lighting in the elevator has four incandescent globes rated at 50 watts each. Describe a practical solution to reduce the energy consumption of the lighting in the lift. Justify how the reduction in energy use would be achieved.

---

---

---

2 marks

**TURN OVER**

**Formula sheet**

Gear ratio final = gear ratio 1  $\times$  gear ratio 2

$$\text{Efficiency} = \frac{\text{output energy}}{\text{input energy}} \times 100\%$$

Voltage = current  $\times$  resistance

$$\text{Resistors in parallel: } R_t = \frac{R_1 \times R_2}{R_1 + R_2}$$

Colour codes

Colour	Value
black	0
brown	1
red	2
orange	3
yellow	4
green	5
blue	6
violet	7
grey	8
white	9
gold	5%
silver	10%

Resistors in series:  $R_t = R_1 + R_2$

Power = voltage  $\times$  current

Area of circle =  $\pi r^2$  ( $\pi = 3.14$ )

Circumference of circle =  $2\pi r$

Force = pressure  $\times$  area

$$\frac{\text{gear A rpm}}{\text{gear B rpm}} = \frac{\text{number of teeth gear B}}{\text{number of teeth gear A}}$$

$$\frac{\text{pulley A rpm}}{\text{pulley B rpm}} = \frac{\text{radius of pulley B}}{\text{radius of pulley A}}$$

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{Gear ratio} = \frac{\text{number of teeth on driven gear}}{\text{number of teeth on driver gear}}$$

$$\text{Mechanical advantage} = \frac{\text{load}}{\text{effort}}$$

Torque = force  $\times$  distance

$$\text{Frequency} = \frac{1}{\text{period}}$$

**END OF QUESTION AND ANSWER BOOK**