VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2014

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER | | | | | | | | | Letter |

SYSTEMS ENGINEERING

Written examination

Monday 17 November 2014

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

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	32	32	80
			Total 100

- 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 27 pages, including formulas on page 27.
- 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.
Unless indicated, diagrams are not to scale.

Question 1

Which one of the following is the best tool to tighten or loosen a hexagon nut fastener?

A. pliers
B. multigrips
C. ring spanner
D. adjustable wrench

Question 2

Compressed air is used to power many workshop tools.
What safety equipment should be worn when using a compressed air blower?

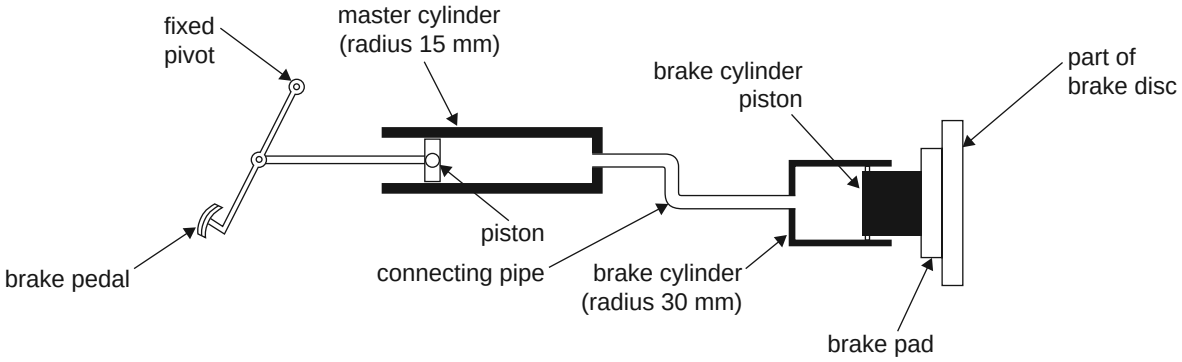
A. gloves
B. hair net
C. safety boots
D. safety glasses

Question 3

Simple machines are the building blocks of all machinery.
The correct names of the six simple machines are

A. screw, lever, inclined plane, pulley, wedge, wheel and axle.
B. screw, lever, inclined plane, wedge, friction, wheel and axle.
C. bolts, pivots, pulley, frame, wheel, axle.
D. bolts, pivots, frame, belt, wheel, axle.

Use the following information to answer Questions 4–6.



Question 4

To what class of lever does the brake pedal belong?

A. first

B. second

C. third

D. fourth

Question 5

The force exerted on the brake cylinder piston

A. depends on the length of the brake cylinder.

B. depends on the length of the connecting pipes.

C. is less than the force exerted on the master cylinder piston.

D. is greater than the force exerted on the master cylinder piston.

Question 6

If the fluid pressure in the master cylinder is 40 kPa, the fluid pressure in the brake cylinder is

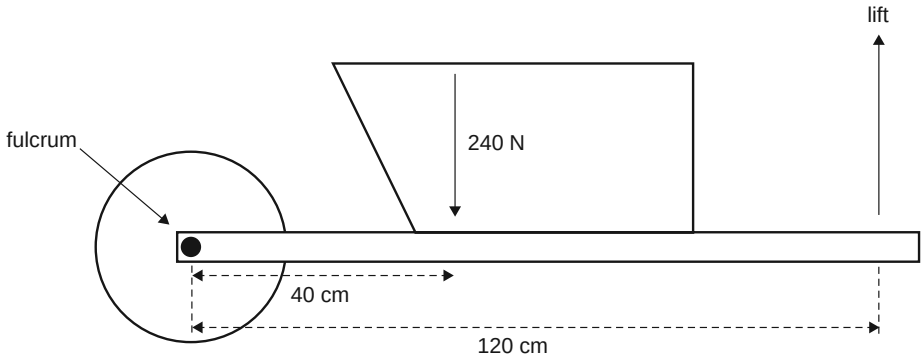
A. 10 kPa

B. 20 kPa

C. 40 kPa

D. 160 kPa

Question 7



What is the force required to lift the handle of the wheelbarrow in the diagram above?

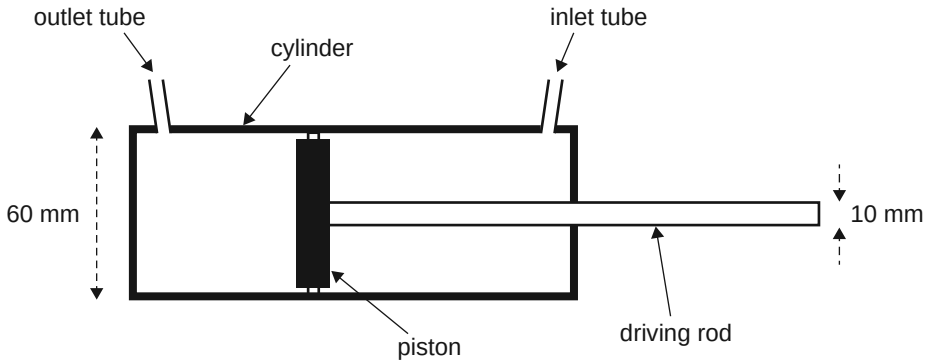
A. 80 N

B. 120 N

C. 480 N

D. 720 N

Question 8



If the pressure of the fluid from the inlet tube is 40 kPa, then the force of the driving rod is closest to

A. 100 N

B. 110 N

C. 113 N

D. 452 N

Question 9

Which type of renewable energy is most affected by the moon?

A. tidal

B. solar

C. wind

D. hydro-electric

Question 10

A force of 1.63974 N expressed to three significant figures is

A. 1.63 N

B. 1.639 N

C. 1.64 N

D. 1.640 N

Question 11

The operation of a mercury switch uses the fact that mercury is a good

A. conductor.

B. insulator.

C. semiconductor.

D. solid.

Question 12

Voltmeters are usually connected for test purposes in

A. pairs.

B. series.

C. parallel.

D. combination.

Question 13

A 1 kW solar panel is 25% efficient.

How much energy needs to fall on the solar panel for it to produce 1 kW?

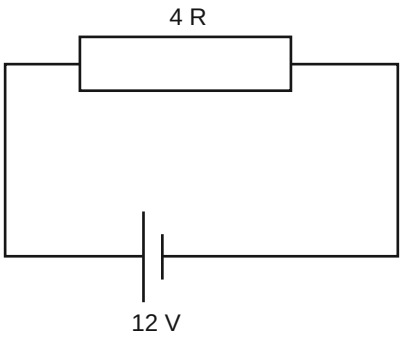
A. 1 kW

B. 4 kW

C. 250 W

D. 1250 W

Question 14



What is the power produced in the circuit above?

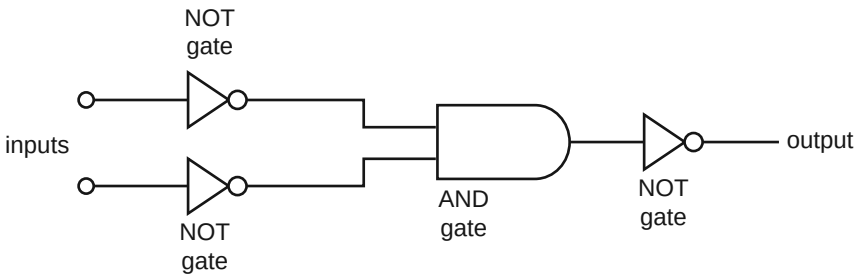
A. 3 W

B. 16 W

C. 36 W

D. 48 W

Question 15



Which one of the following single gates could replace the four logic gates shown above?

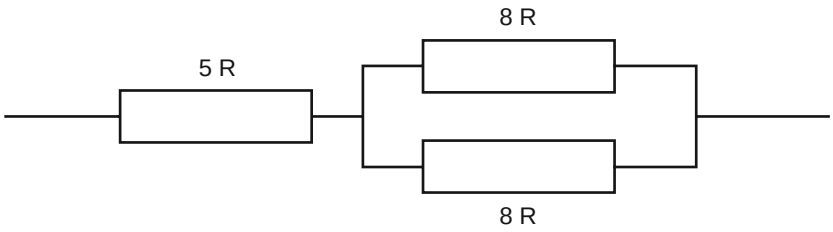
A. AND

B. XOR

C. NOR

D. OR

Question 16



What is the total resistance of the resistor network shown above?

A. 21 R
B. 13 R
C. 11 R
D. 9 R

Question 17

After the design brief, the next step in the Systems Engineering Process is to

A. design the product.
B. research components and costs.
C. re-evaluate and modify the design brief.
D. complete a time line and materials list.

Question 18

A hydrogen cell, or fuel cell, works by

A. converting water to hydrogen and oxygen, and then burning the hydrogen to get electricity.
B. converting water to hydrogen and oxygen, and then burning the oxygen to get electricity.
C. combining hydrogen and oxygen in an electrolyte to get water and electricity.
D. burning hydrogen and oxygen together to get water and electricity.

Question 19

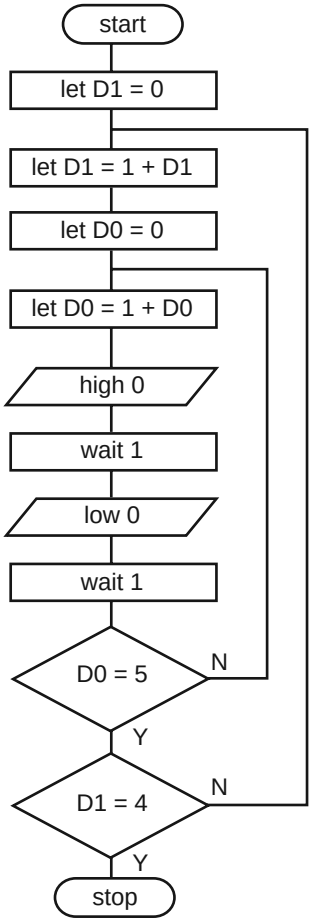
A solar cell array produces 6 kWh over 12 hours.

The average power output of the solar cell array is

A. 2 W
B. 500 W
C. 2 kW
D. 72 kW

Question 20

The flow chart of a microcontroller program is shown below.



'High 0' turns a light-emitting diode (LED) on. 'Low 0' turns it off. 'Wait 1' is a one-second delay.

For how long will the LED flash on and off in this program?

A. 2 seconds

B. 9 seconds

C. 20 seconds

D. 40 seconds

END OF SECTION A

CONTINUES OVER PAGE

SECTION B

Instructions for Section B

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

Unless indicated, the diagrams are not to scale.

The following information relates to Questions 1–31.

Early washing machines involved boiling dirty clothes in a copper water container called a Copper, with a small amount of pure soap. The boiling action agitated the clothes to remove dirt. Excess water was removed from the clothes by passing them through a wringer. The excess water was collected in a basin.

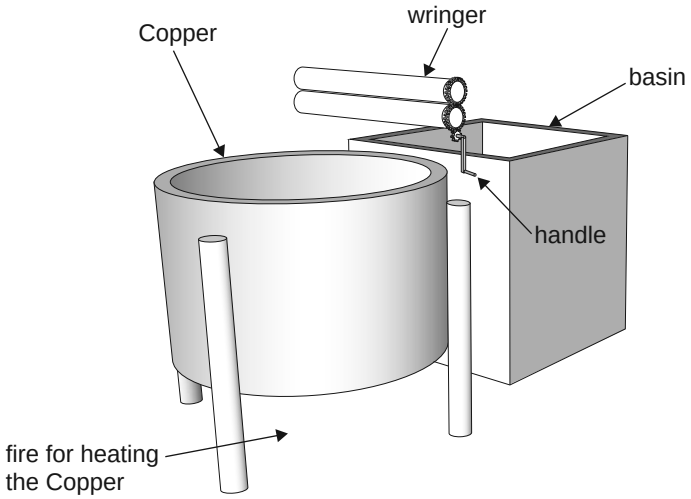


Figure 1

On the wringer mechanism shown in Figure 2 below, Gear A has eight teeth and Gears B and C both have 24 teeth.

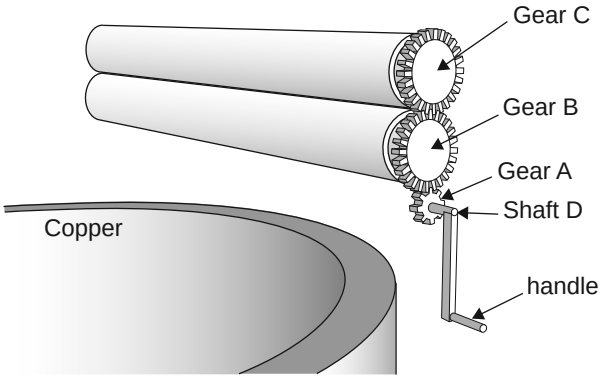


Figure 2

Question 1 (1 mark)

Identify the type of motion of the handle.

Question 2 (1 mark)

In which direction does the handle move as the clothes pass through the wringer?

Question 3 (1 mark)

Calculate the gear ratio of the gear train.

Question 4 (2 marks)

The operator exerts a turning force of 50.0 N on the handle shown in Figure 3 below.

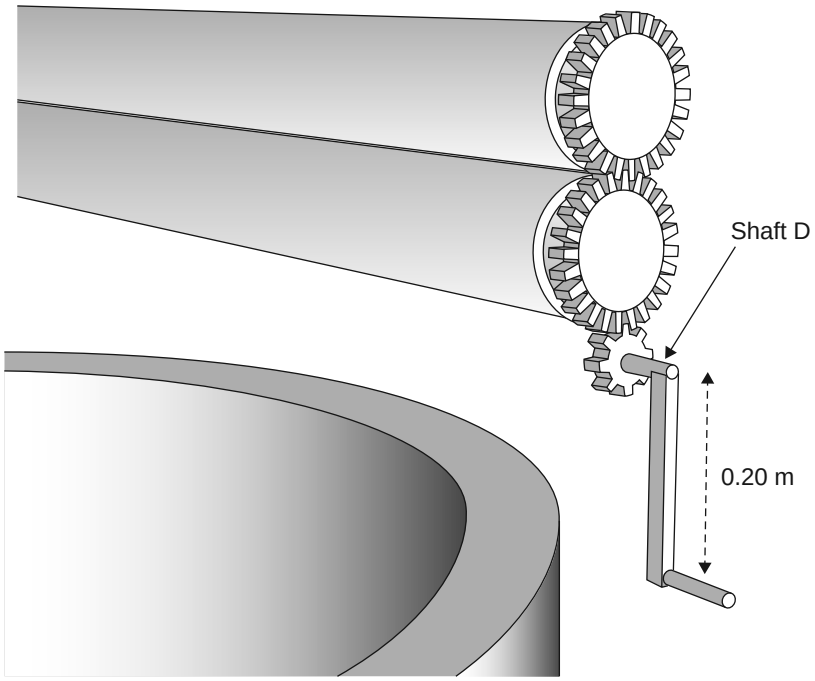


Figure 3

Calculate the torque applied to Shaft D. Show your working.

Nm

Question 5 (2 marks)

The distance between the wringer rollers needs to be adjustable to allow for the varying thickness of clothes. (All gears have 24 teeth.)

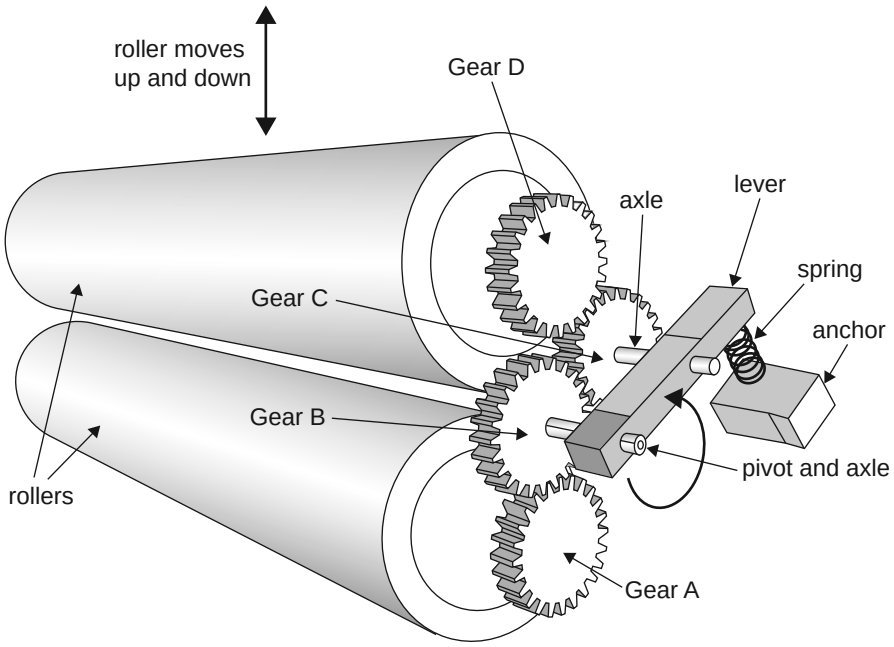


Figure 4
not to scale

Give two reasons for using a pivoted double-gear system between Gears A and D in Figure 4.

1. _____

_____

2. _____

_____

Question 6 (1 mark)

Identify the type of force applied to the spring in Figure 4.

_____

_____

Question 7 (2 marks)

Describe how the system in Figure 4 ensures continuous engagement of the gear train as the top roller is raised and lowered.

_____

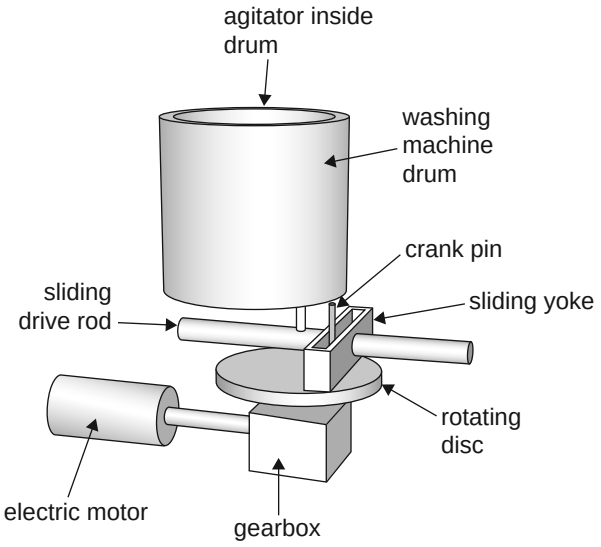
_____

Question 8 (1 mark)

Identify **one** important safety reason explaining why the type of wringer shown in Figure 4 is no longer used.

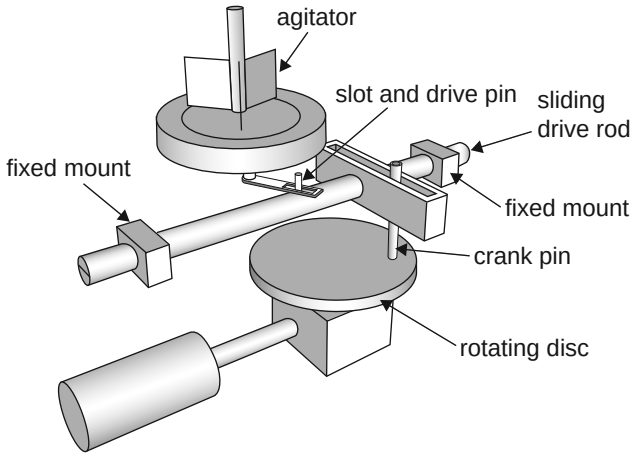
Question 9 (4 marks)

Years later, washing machines with an agitator and a drum were developed. The washing machine is driven by a sliding yoke mechanism. The washing machine uses an agitator and not boiling water to clean the clothes. Water at a lower temperature can then be used in the machine. Figures 5a and 5b below show how the machine works.



washing machine mechanism with a drum

Figure 5a



washing machine mechanism without a drum

Figure 5b

Give the type of motion for each component identified in the table below.

Component	Type of motion
rotating disc	
drive rod	
sliding yoke	
agitator	

Question 10 (1 mark)
The slide mounts are made of aluminium and wear out on a regular basis.

Suggest a practical solution to reduce wear on the slide mounts.

Question 11 (1 mark)
How can the length of stroke of the sliding drive rod be altered?

Question 12 (3 marks)
In the table below, identify three different types of energy that are used as the washing machine operates. State the location of each type of energy in the washing machine.

Type of energy	Location of type of energy
1.	
2.	
3.	

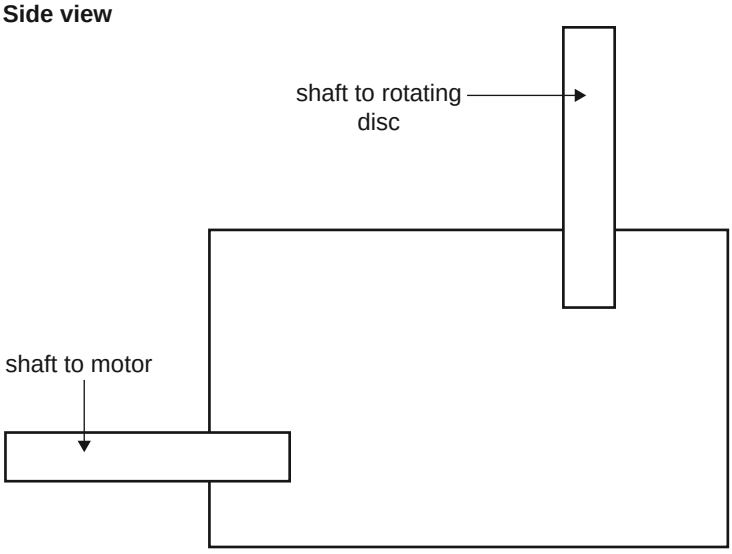
Question 13 (5 marks)

A gearbox will be designed to reduce the number of revolutions of the motor from 1000 rpm to 40 rpm. The following gears are available for use.

Bevel gears (teeth)	Spur gears (teeth)	Other available gear types
10	10	single thread worm
25	25	gear rack
50	50	
125	125	

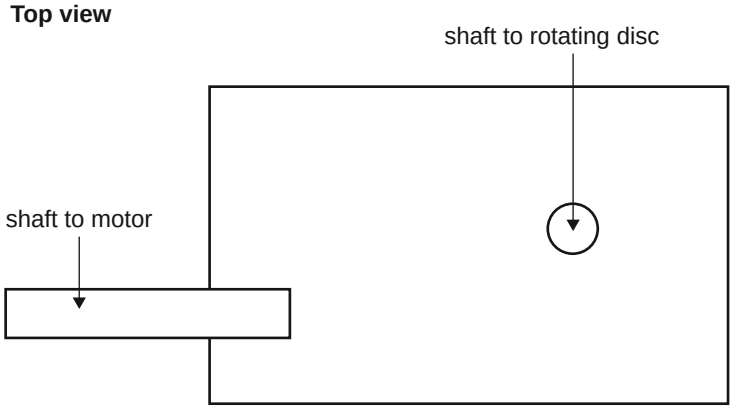
Design a gearbox that can have a reduction ratio of 1:25. Label and give the number of teeth for each type of gear used. Use **either** the side view **or** the top view provided below.

Side view



OR

Top view



Question 14 (8 marks)

In the life cycle of a washing machine, there are three main phases. These phases are manufacture, operation and disposal. The operational phase has two subsections: operational energy supply and operational water supply.

Using the table below, identify one environmental cost for each phase and then suggest a method of reducing that environmental cost.

Life-cycle phases of a washing machine	**Environmental cost**	**Method of reducing the environmental cost**
1. manufacture		
2a. operational energy supply		
2b. operational water supply		
3. disposal		

Question 15 (1 mark)

The washing machine has a 240 V AC power supply. The electronic circuitry of the washing machine uses 12–14 V DC. A transformer reduces the 240 V AC to 15 V AC. The circuit diagram below shows how this can be achieved.

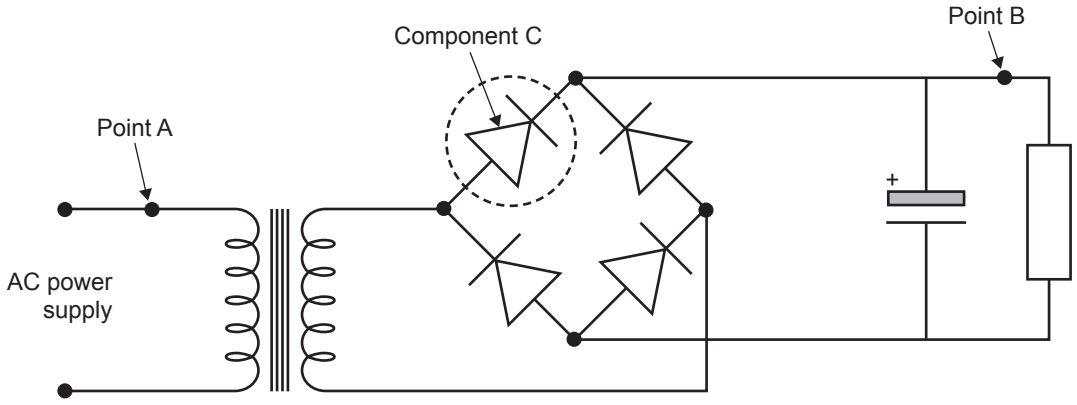


Figure 6

Name Component C shown in Figure 6 above.

Question 16 (2 marks)

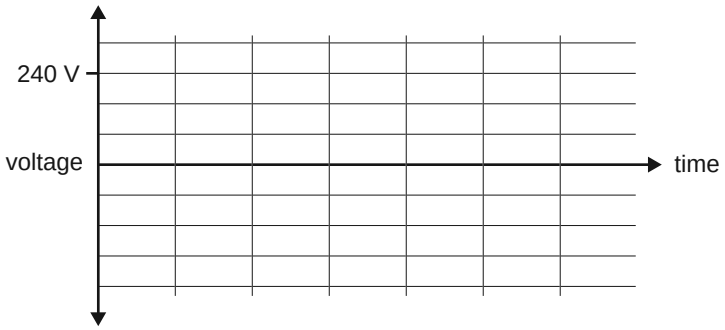
Given that there are 2000 primary windings in the transformer, calculate the number of secondary windings.

Show your working. Use the formula $\frac{V_S}{V_P} = \frac{N_S}{N_P}$.

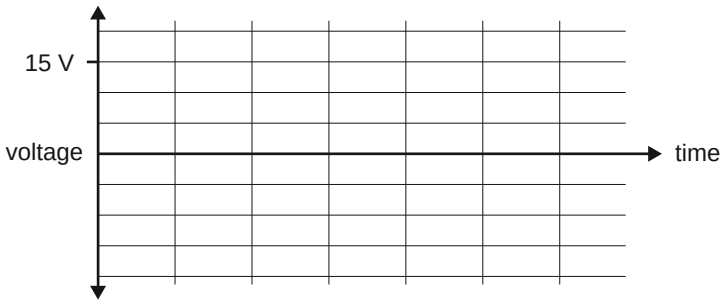
windings

Question 17 (4 marks)

a. Sketch the wave form at Point A shown in Figure 6. 2 marks



b. Sketch the wave form at Point B shown in Figure 6. 2 marks



Question 18 (2 marks)

At the end of the wash cycle, the circuit below is activated. The circuit generates a tune and turns on a light-emitting diode (LED).

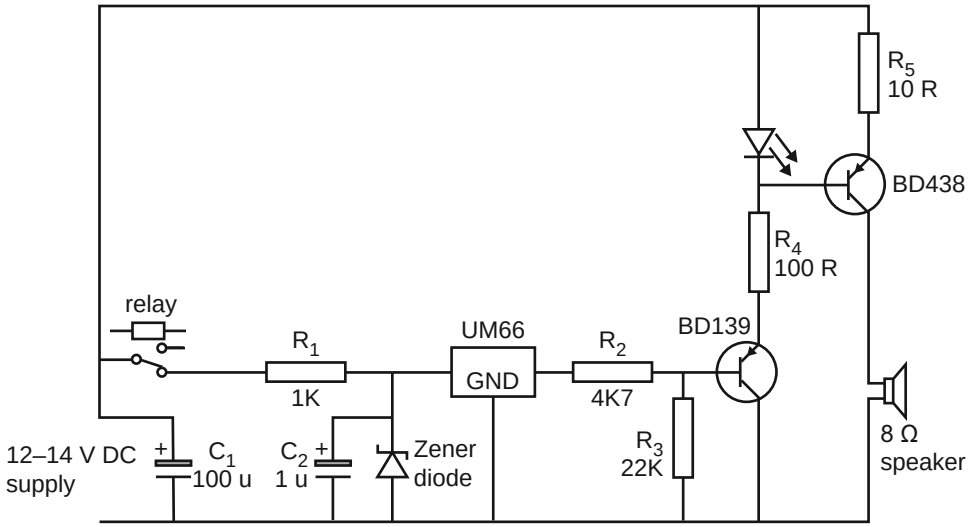


Figure 7

a. What test equipment is required to check that the speaker works? 1 mark

_____

b. What specific result would you expect if the speaker is working? 1 mark

_____

Question 19 (3 marks)

a. Give the four-colour code of R_5, if it has a tolerance of 5%. 1 mark

_____

b. State the lowest and highest resistance readings that could be obtained if an ohmmeter was used to test if resistor R_5 was serviceable. 2 marks

Lowest resistance reading _____ ohms

Highest resistance reading _____ ohms

Question 20 (1 mark)

BD438, shown in Figure 7, is a power transistor. Some power transistors produce a lot of heat.

How can the overheating of a power transistor be reduced while it is operational?

Question 21 (2 marks)

The BD438 power transistor was found to be faulty and no replacements were available. The table below gives some possible alternative transistors that could be used.

Type	PNP/NPN	VCE max	IC max	hfe
BC131	NPN	45	15	>40
BC132	PNP	45	15	>40
BD139	NPN	80	8	>40
BD140	PNP	80	8	>40
BD437	NPN	45	36	>85
BD438	PNP	45	36	>85
BD679	NPN	80	40	>750
BD680	PNP	80	40	>750

Select an appropriate replacement transistor from the table above.

Give reasons for your selection.

Question 22 (2 marks)

A washing machine is a hostile environment for electronic equipment.

Suggest two factors that need to be considered in the design and placement of any electronic circuits in a washing machine.

1. _____

_____

2. _____

_____

Question 23 (3 marks)

The new transistor to be used in the circuit shown in Figure 7 has a different pin configuration from the BD438 transistor, so a new printed circuit board needs to be constructed.

Indicate the correct order of the processes for the construction of the printed circuit board by writing the appropriate numbers (1 to 7) in the table below.

Process	Order
Drill the circuit board.	
Etch the circuit board.	
Select the components.	
Design the circuit board.	
Test the circuit board.	
Simulate the circuit.	
Install the components of the circuit board.	

Question 24 (2 marks)

Identify two processes, used in the construction of the printed circuit board, where people may be exposed to the risk of injury.

1. _____

2. _____

Question 25 (5 marks)

A water sensor is to be used as part of a water-level control system in the washing machine.

a. On Figure 8, design a safe water-level sensing device that will detect water overflow and send a warning signal to the control box. Label all parts relevant to your design. 3 marks

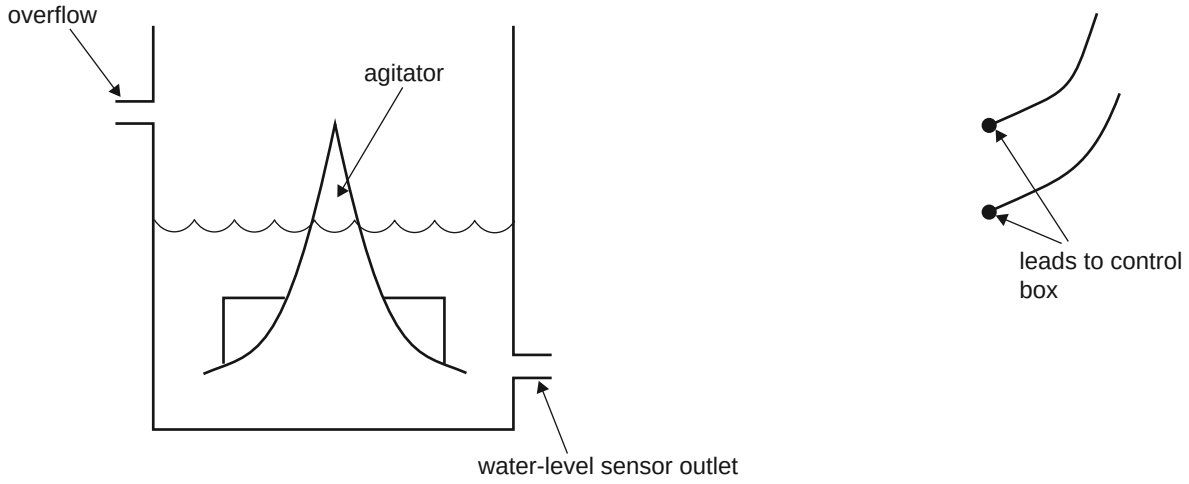


Figure 8

b. Describe how your water-level sensing device works. 2 marks

Question 26 (2 marks)

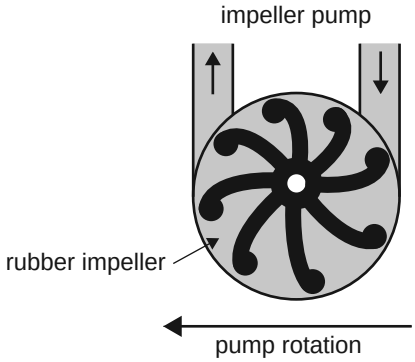


Figure 9

Some washing machines use an impeller pump to get rid of wastewater.

Use the diagram above to describe how an impeller pump works.

Question 27 (2 marks)

A washing cycle consists of a wash phase, and a spin and rinse phase. The wash phase requires 620 W and lasts for exactly 30 minutes. The spin and rinse phase requires 160 W and lasts for 15 minutes.

Calculate the energy required for a complete wash cycle. Show your working. The formula for energy is: energy = power × time

Question 28 (2 marks)

When the washing machine is used in a remote location, a solar panel system is used to provide energy for the operation of the washing machine. The solar panel system produces an average of 400 W of power and generates an average of 3.2 kWh of energy each day.

Calculate the average number of hours that the sun shines on the solar panel system each day. Show your working.

Question 29 (2 marks)

The electrical energy from the solar panels is required to pass through an inverter and is stored in a battery pack. The inverter is 95% efficient and the batteries are 75% efficient.

Calculate the efficiency of the inverter and battery system. Show your working.

Question 30 (3 marks)

The inverter requires an input voltage of 24 V, but only 12 V batteries are available.

a. Using **all** of the batteries shown in Figure 10 below, draw the connections to the batteries to give a 24 V output. 2 marks

b. Draw an ammeter in the circuit below, so that the ammeter will show the total current. 1 mark

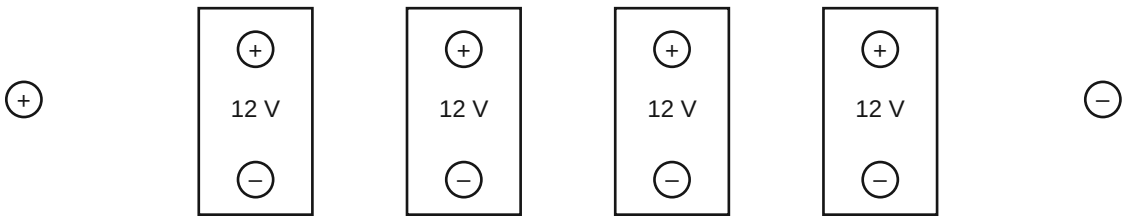


Figure 10

Question 31 (4 marks)

a. Apart from the water sensor, name **two** other possible input devices for the washing machine. 2 marks

b. Give **two** possible output devices for the washing machine. 2 marks

Question 32 (5 marks)

Delivery drones

Many companies now sell their products over the internet and use the postal service for deliveries.

However, recently, a large online bookseller in America decided to try delivering its books to customers using an unmanned drone that could fly within a 16 km radius of the company depot. In a test flight, a four-propeller unmanned drone delivered a 2 kg book container to a house in a nearby suburb.

Currently in America, people are not allowed to operate drones, but this rule will be reviewed in 2015. In Australia, people who operate a drone must have a commercial pilot qualification.

Discuss the issues that need to be resolved before drones could become a regular method of delivery in Australia.

END OF SECTION B

Formula sheet

gear ratio final = gear ratio 1 × gear ratio 2

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

voltage = current × 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 × current

area of circle = πr^2 ($\pi = 3.14$)

circumference of circle = $2\pi r$

force = pressure × 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 × distance

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

$\text{efficiency}_{\text{Total}} = \text{efficiency}_1 \times \text{efficiency}_2$

END OF QUESTION AND ANSWER BOOK