Design and Technology

Year 12 Engineering Studies

ATAR Units 3 and 4

2018

MECHATRONICS

Booklet 1: Core theory

Student: ______________________________

Teacher: Mr Čečins and Mr Tilley

1. Engineering design process

Investigating

a. Develop comprehensive design brief

b. Identify and assess existing solutions or similar products using a variety of research skills

c. Research and critique materials and components relevant to the design brief

d. Consider different and appropriate sources of energy.

Devising

a. Produce annotated pictorial drawings of design ideas

b. Produce annotated orthographic drawings of design ideas

c. Analyse and justify the choice of option to be used as the solution.

Producing

a. Present specifications for the selected solution:

   (i) dimensioned pictorial and orthographic drawings

   (ii) orthographic drawings and sketches
   - 3rd angle projections
   - lines (outlines, hidden detail and centrelines)
   - dimensioning (linear, radii, circles and holes)

   (iii) materials selection

   (iv) parts lists

   (v) costing of prototype or working model

b. Develop and use timeline for construction and testing of solution

c. Construct solutions by selecting and using appropriate tools and machines and by following safe work practices

d. Test the solution for correct function and document using checklists and test data.

Evaluating

Evaluate the final solution in terms of:

   (i) meeting the requirements of the design brief

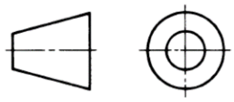
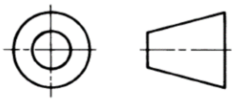
   (ii) safety, function and finish of product

   (iii) modifications and changes to the design and processes during production

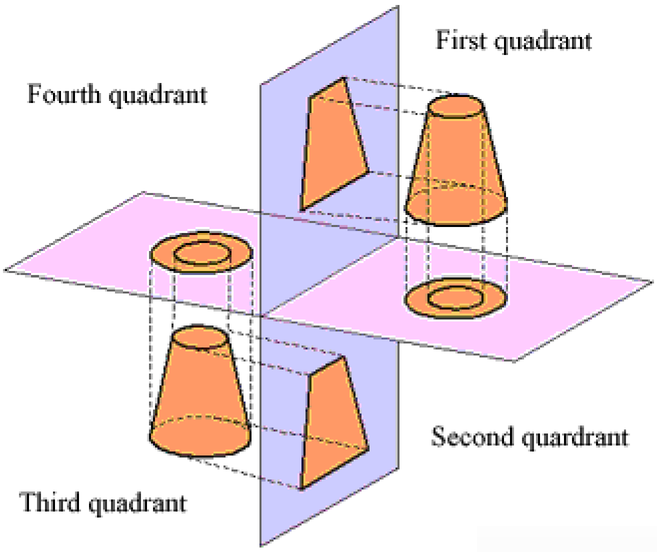
   (iv) refinements and changes for future development.

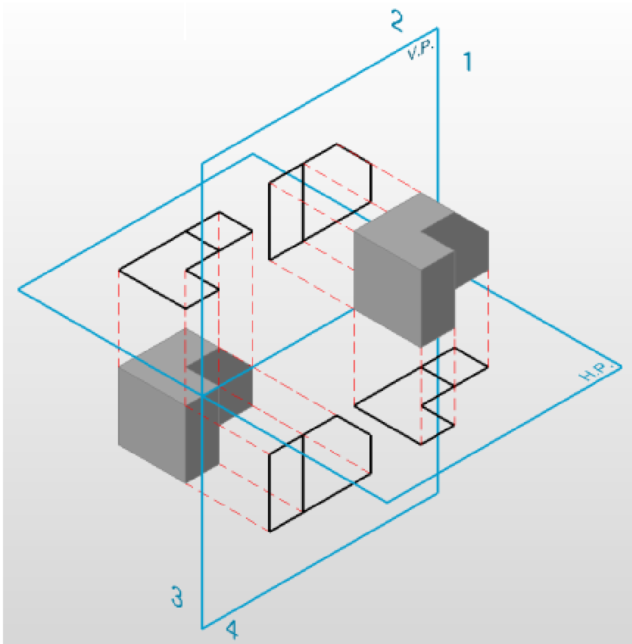
Orthographic projections

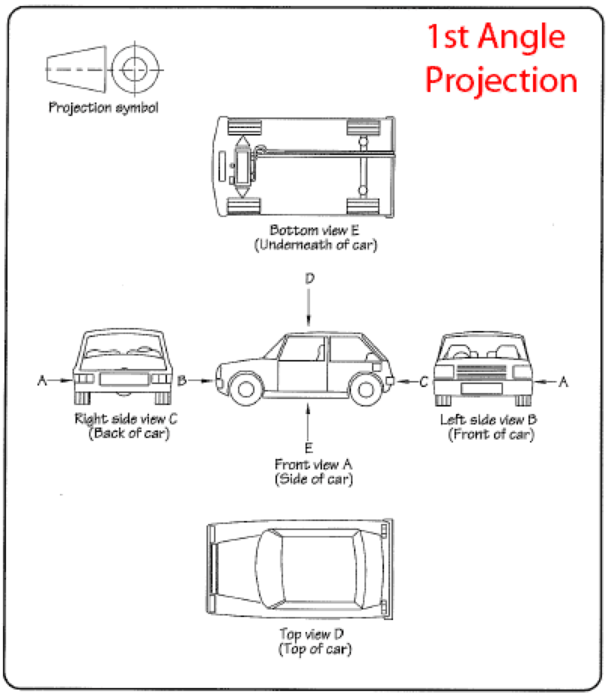
These can take the form of first or third angle. **Third angle projection** is used for this course of study. The symbols for each is shown below.

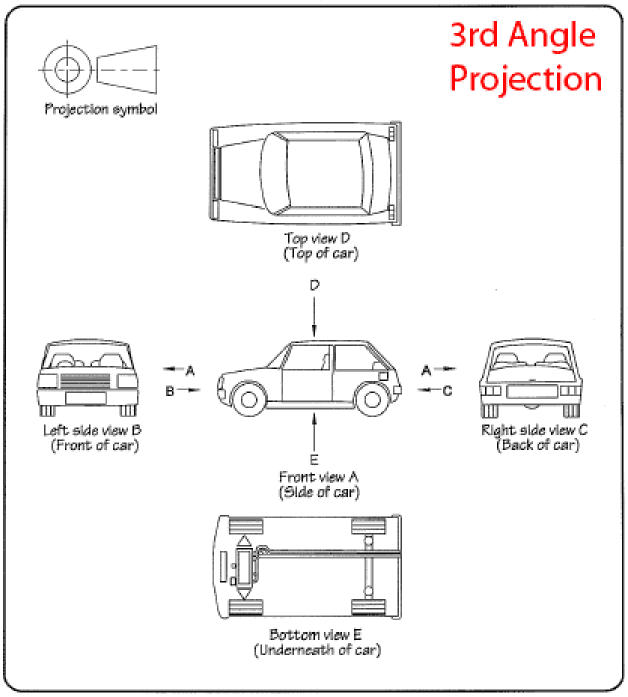
Projection	Symbol
First angle	
Third angle	

Illustrated below are images that demonstrate these forms of orthographic projection.



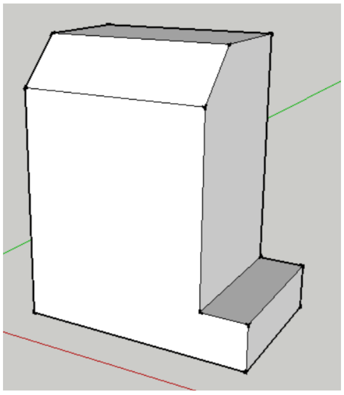



1st Angle
Projection
Projection symbol
Bottom view E
(Underneath of car)
D
A
B
C
A
Right side view C
(Back of car)
Left side view B
(Front of car)
E
Front view A
(Side of car)
Top view D
(Top of car)


3rd Angle
Projection
Projection symbol
Top view D
(Top of car)
D
A
B
A
C
Left side view B
(Front of car)
Right side view C
(Back of car)
E
Front view A
(Side of car)
Bottom view E
(Underneath of car)

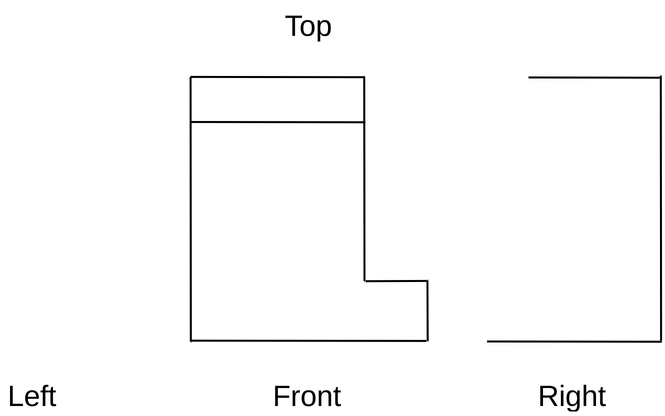
1. Sketch the symbol for third angle projection

2. Examine the pictorial drawing shown below.



The front view and partially completed right end view are given below. Complete the right end view and add the top and left end views.

Note: Back and bottom views are not required for this exercise but might be required for more advanced drawings.



Lines

Continuous - thick	Visible outline
Dashed - thin	Hidden
Chain - thin	Centre lines
Continuous – thin	Dimension lines (arrowed) Projection lines Leaders

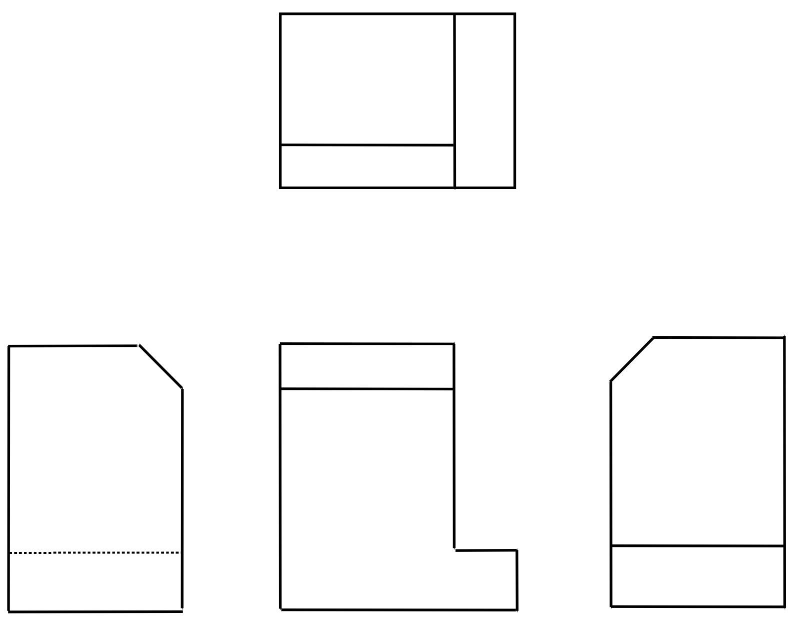
Precedence of lines

Visible outlines take precedence over all other lines.

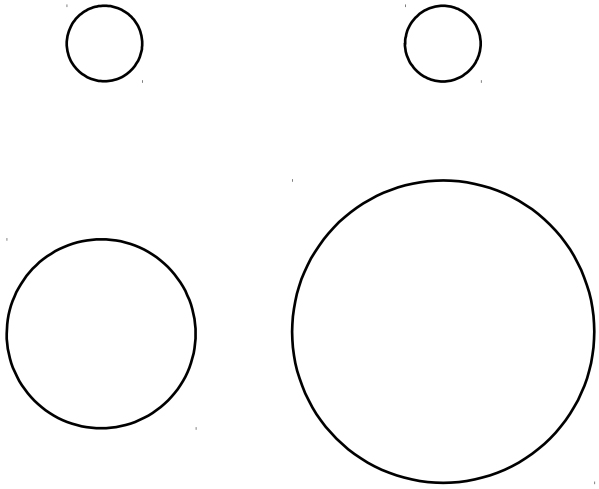
Hidden lines take precedence over centre lines.

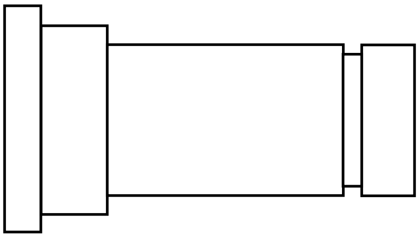
Dimensioning

On the following third angle projection drawing add projection and dimension lines such that all features are dimensioned.

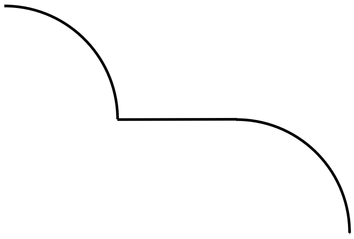


On the following drawings of circles and cylinders add centrelines, projection and dimension lines, and leaders as required.





On the following drawing add dimension lines to indicate internal and external radii.



More questions

WACE 2009 multiple-choice questions 3, 5 and 8; extended core question 1; extended core question 3 (a), (b) and (c); and extended core question 4.

WACE 2010 multiple-choice questions 1, 2, 3, 4, 6, 7, 8, 9 and 10; question 11 (a); question 12 (a), (b) and (c); question 13 (a), (b) and (c); and question 14 (a) (i) and (ii), (b), (c) and (d).

WACE 2011 multiple-choice questions 1, 3, 4, 5, 9 and 10; question 11 (a), (b), (c), (d), (e), (f), (g) and (h); question 12 (a), (b), (c) and (d); question 13 (a); and question 14.

WACE 2012 multiple-choice questions 1, 2, 3, 4, 7 and 9; question 11 (a), (b) and (c); and question 14 (a) – (h).

WACE 2013 multiple-choice questions 5 and 6; and question 12 (a), (c) and (d); and question 13 (a).

WACE 2014 multiple-choice questions 4, 8, 9 and 10; and question 11 (a) and (c).

WACE 2015 multiple-choice question 8.

WACE 2016 multiple-choice questions 1, 4, 5, 8 and 9; and question 13 (a).

WACE 2017 multiple-choice questions 3, 4 and 5; question 12 (b), (d), (e), (f) and (g): and question 13 (a).

Addition reading

The following link is for a very useful resource used by schools in Victoria.

http://www.vcaa.vic.edu.au/documents/vce/visualcomm/technical_drawing_specifications.pdf

2. Energy, work and power

What is energy?

Definition: ____

____

It is generally accepted that there are two major forms of energy. These are kinetic energy (E_K, the energy in moving particles) and potential energy (E_P, energy that is stored due to the relative positions of particles). The total energy in a system tends to be a mixture of the two forms and the relative quantities of each will change with circumstances. As a general description $E_T = E_K + E_P$.

Specific types include: mechanical, gravitational, thermal, chemical, electromagnetic (e.g. electrical and light), electro-chemical and nuclear.

Sources of energy may be renewable or non-renewable. These include:

Non-renewable sources:
Fossil fuels (coal, gas and oil)

Nuclear

Renewable sources of energy:
Solar (thermal, biomass, photovoltaic, wind and waves)

Gravity (tidal and hydroelectric)

Geothermal

Conservation of energy

The conservation of energy is the concept that energy cannot be created nor can it be destroyed. Rather, it changes form. For example, chemical energy in a battery is converted into electrical energy that is transferred to a light bulb and changed into light and heat, both of which are also forms of energy.

In electrical and electronic circuits the application of **Kirchhoff's Voltage Law is an example of the conservation of energy.** It is a means for accounting where energy is located in a circuit in the form of potential differences (or voltage drops).

How is energy measured?

In general terms, energy = power $\times$ time or $E = Pt$.

Energy is measured in units of joules (J) and kilo-watt hours (kWh).

1 J = 1 W $\times$ 1 s   and   1 kWh = 1000 W $\times$ 1 h

J = joules of energy, W = power in watts, s = time in seconds and h = time in hours

What is work?

Definition: ____

____

The formula for work is $W = Fs$, where W is work (note the W is italicized and must not be confused with the abbreviation W used for watts which is the unit for power), F is force and s is displacement.

The unit of work is also the joule (J). In general terms 1 J = 1 N $\times$ 1 m = 1 Nm

Example (general): A man pushing a car along a level road is said to be doing work. The amount of work done depends on the force exerted and the distance through which the force acts.

Example (electrical): The charging of a capacitor requires work to move electric charges onto the plates of the capacitor and this will result in a potential difference (voltage) between the plates.

In electrical circuits the formula is $W = Vq$ or VQ 1 J = 1 V $\times$ 1 C

W = work (joules), V = voltage and q or Q = charge (coulombs).

What is power?

Definition: ____

____

The unit of power is the watt (W) and in general terms 1 W = 1 J s^{-1} or $P = \frac{E}{t}$

J = energy in joules, s = time in seconds, P = power (watts), E = energy (joules) and t = time (seconds)

Example (general): A builder brings 1000 blocks each of mass 20 kg from the ground, up a ladder, to the top of a house. It takes him 5 hours to do so. A crane lifts all the blocks together from the ground to the top in a time of 10 seconds. Even though the man and the crane do the same work the crane does it in a much shorter time. The crane is much more powerful than the man.

Example (electrical): A bulb in a desk lamp can convert electrical energy into heat and light at the rate of 40 joules per second; a bulb in a floodlight can convert electrical energy into heat and light at the rate of 500 joules per second. The second bulb is more powerful than the first.

In an electrical circuit P = J s^{-1} $= VI = RI^2 = \frac{V2}{R}$

P = power in watts (W), J = energy in joules, s = time in seconds, V = voltage,

I = current in amperes (A) and R = resistance in ohms (Ω)

1. Describe the relationships between energy, power and work.

2. Describe examples for each of the following forms of energy.

(a) Kinetic

The energy a body has due to its motion is kinetic energy.

Examples:

(b) Potential

Potential energy is the energy in an object due to its position or the arrangement of its parts. It includes gravitational, elastic, chemical and electromagnetic potential energy.

Examples:

(c) Thermal (heat)

A form of energy which transfers among particles in a substance (or system) by means of kinetic energy of those particles i.e. heat is transferred by particles bouncing into each other.

Examples: ____________________

Note: Temperature is different from heat, though the two concepts are linked. The total thermal energy will include its temperature (E_K) and stored (E_P) components.

(d) Chemical

The energy given out (or sometimes taken in) in the form of heat, light or kinetic energy during a chemical reaction is called chemical energy.

Examples: ____________________

(e) Electrical (Electromagnetic)

Electrical energy is the movement of electrons through a conductor.

Examples: ______________________________

____

____

____

____

____

(f) Electrochemical

The production of electrical energy from chemical energy.

Examples: ______________________________

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____

(g) Electromagnetic (light)

Energy transmitted from one point to another in the form of electromagnetic waves that travel at the speed of light.

Examples: ______________________________

____

(h) Nuclear

The energy given out from the nuclei of certain atoms during nuclear reactions (fission or fusion) is called nuclear energy.

Examples:

3. Sources of energy can be described as non-renewable and renewable.

(a) What is meant by the terms *non-renewable and renewable sources of energy*?

(b) Give examples for each of the following sources of **non-renewable** energy

(i) Fossil fuels

A hydrocarbon deposit derived from living matter of a previous geologic time.

Examples: ______________________________

____

(ii) Nuclear

Energy released by the nucleus of an atom as the result of nuclear fission or fusion.

Examples: ______________________________

____

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____

____

____

(c) Give examples for each of the following sources of **renewable** energy.

(i) Solar

Energy derived from the sun's radiation**.**

Examples: ______________________________

____

____

____

(ii) Gravity

Energy derived from a mass as a result of gravity acting on the mass that converts potential energy into kinetic energy.

Examples: ______________________________

(iv) Geothermal

Energy derived from the heat in the interior of the earth. Magma intrusions (molten rock from the earth's mantle) and radioactive decay of rocks are two of the main causes of this heat. It is estimated that the temperature gradient for the crust of the earth is about 2.5 – 3.0 ºC per 100 meters of depth but this can vary quite dramatically at different locations.

Examples: ______________________________

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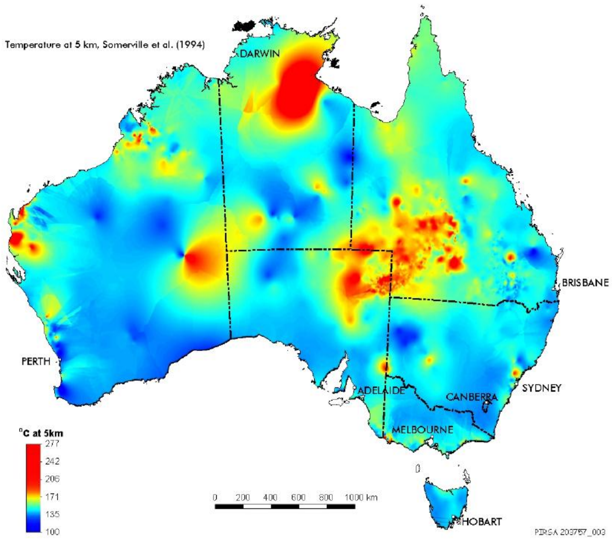
How to calculate your power bill

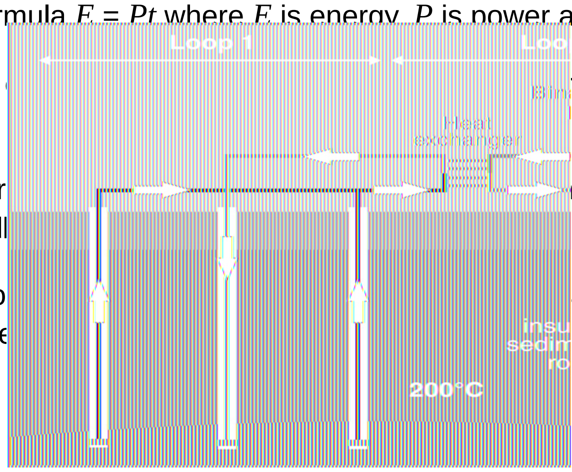


It is one of life's peculia Nevertheless, you pay for the '*power*' ppliances are costing you to run:

Check the wattage (pc a small label attached to the applianc

Note: Appliances with t ull wattage all the time. To work out hc e wattage and use this number for the

(a) Multiply the wat is used over the period you w the number of kilowatt hours y ergy and this complies with the formula $E = Pt$ where E is energy, P is power and t is time.



(b) Multiply the number nt domestic tariff in Western Australia).

(c) Remember that ther day for domestic consumption, regardl

The following guide tells yo appliances. Those marked with a (T) have a the

4. It is Sunday morning and it is time for breakfast. The kettle (2400 W) is boiled for 3

Air conditioner (T) 2.5 HP	= 7000 W
Ceiling fan	= 80 W
Clothes dryer	= 2500 W
Computer	= 250 W
Dishwasher	= 2400 W
Fridge (2 door frost free) (T)	= 230 W
Hair dryer	= 1000 W
Heater (double bar)	= 1800 W
Iron	= 1000 W
Kettle	= 2400 W
Light (bulb)	= 100 W
Light (fluorescent)	= 36 W
Microwave oven	= 800 W
Oven (T)	= 1100 W
Radio	= 100 W
Stereo	= 150 W
Television	= 250 W
Toaster	= 1500 W
Vacuum cleaner	= 500 W
Washing machine	= 900 W

minutes and coffee made. The toaster (1500 W) takes 4 minutes before the toast pops up. Two 100 W light bulbs are switched on for half an hour while breakfast is eaten and the paper read. Before leaving the kitchen, the lights are switched off and the coffee mug, plate and cutlery are placed in the dishwasher (2400 W). Together with the dishes from the previous night there is a sufficient load in the dishwasher to justify it being run for a 12 minute cycle.

(a) How much energy was used? Answer in kilo joules (kJ).

____

____

____

Energy used = ________________

(b) If the tariff is 26.47 cents per kWh, then how much did it cost to operate the appliances and lights?

Cost = ________________

Note: There will also be the set daily charge billed to the household that will be added to any other additional consumption charges.

More questions

WACE 2009 multiple-choice questions 1, 4, 7 and 10.

WACE 2010 multiple-choice question 5; and question 13 which is related to issues associated with generating energy.

WACE 2011 multiple-choice questions 6 and 8; and question 14 (a) and (b). The other parts of this question fit the theme but are more akin to the engineering design process and fundamental engineering calculations in nature.

WACE 2012 question 13 (a)(i) and (ii). The other parts of this question are energy related but fit better as examples of fundamental engineering calculations.

WACE 2013 multiple-choice question 7; and question 13 (a), (b), (c) and (d).

WACE 2014 multiple-choice question 4; and question 13 (a), (b)(i), (ii) and (iii) and (c).

WACE 2015 multiple-choice questions 1, 2, 3, 4 and 9; and question 11 (a), (b), (c), (d) and (e).

WACE 2016 multiple-choice questions 2 and 7; question 11 (b)(i), (b)(ii), (e), (f) and question 14 (f) and (g).

WACE 2017 multiple-choice questions 1, 7 and 8; question 11 (b), (e), (f)(i) and (ii), (g) and (h).

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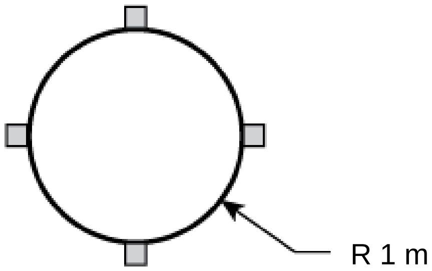
3. Fundamental engineering calculations

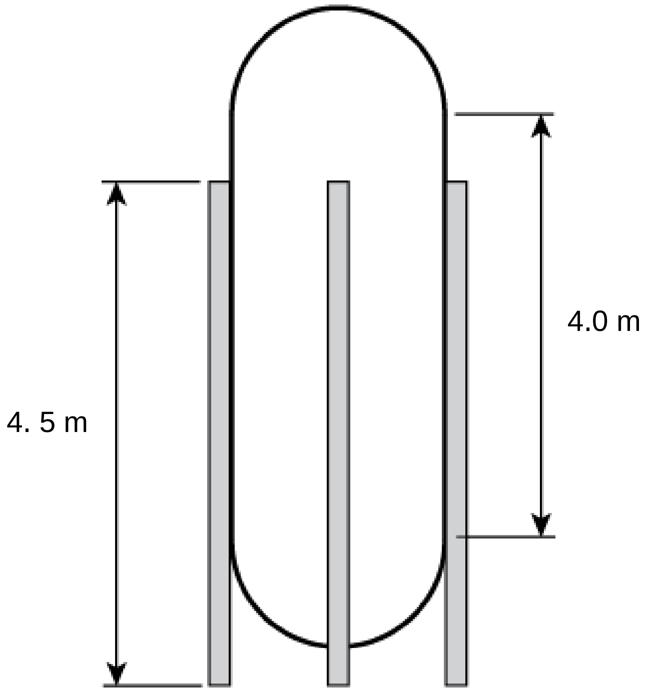
Question 1* **(20 marks)**

* Sourced from 2007 TEE

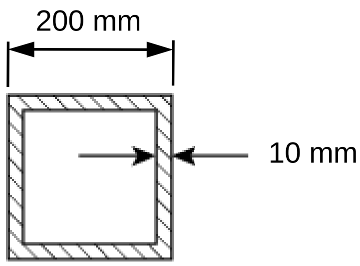
The diagrams below represent a pressure vessel that is designed to contain crude oil. It is supported by four legs.



Plan



Elevation



Detail of leg cross section

The vessel is to be made from structural steel plate of 10 mm thickness formed into a cylinder with hemispherical ends as shown. The four support legs are made from structural steel square tubes.

(a) Calculate the mass of steel required to manufacture the vessel.

Note 1: The legs are to be ignored.
Note 2: It is a good strategy to use units of metres rather than millimetres.
Note 3: The density of structural steel is given in the Data Book.

(7 marks)

Mass of steel (vessel only) = ____________________

(b) Calculate the mass of the steel used for the four support legs. (3 marks)

Mass of steel (four support legs) = ____________________________

(c) Calculate the total mass of the pressure vessel, including the four legs, when the vessel is completely filled with crude oil.

Note: The density of crude oil is given in the Data Book. (5 marks)

Total mass of structure when filled with oil = ____________________

(d) Calculate the compressive stress at the base of **each** support leg.

*Note: Stress is calculated using force/area where force is measured in newtons (mass $\times$ acceleration due to gravity i.e. 9.8) and area in **mm²**.*

(5 marks)

Stress at base of each leg = ______________________________

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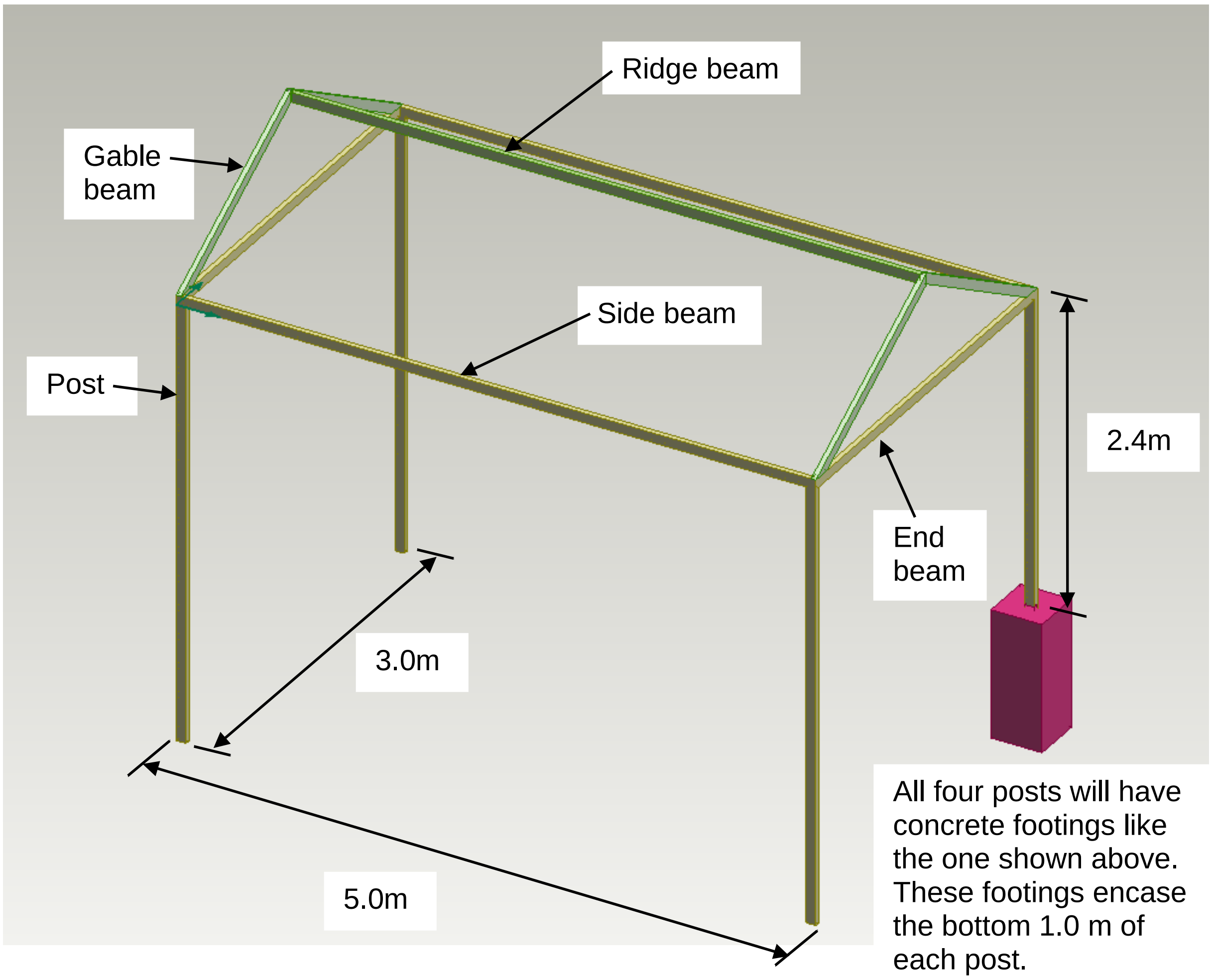
Question 2* **(20 marks)**

* Sourced from 2008 TEE

A pergola is a structure that is often situated in gardens. It usually has a roof and open walls. A freestanding pergola is to be built using 76 mm $\times$ 38 mm rectangular galvanized steel called 'patio tube'. The thickness of the steel in the patio tube is 1.6 mm. Each post of the pergola will be buried in a 1.0 m deep hole then backfilled with concrete to provide a secure foundation (or footing). The angle of the roof is 30°.



(a) Given that the patio tube can be ordered cut to any required length, complete the ordering schedule below.

Note: No need to allow for minor off-cuts where corners or edges meet.

(6 marks)

Name of member	Number of pieces	Length	Total	Marks
Post				1 mark
Ridge beam				1 mark
Side beam				1 mark
End beam				1 mark
Gable beam				1 mark
		Total		1 mark

(b) Calculate the total mass of the patio tube required to construct the pergola.

Note: The density of patio steel is the same as for structural steel. Refer to the Data Book for this information.

(6 marks)

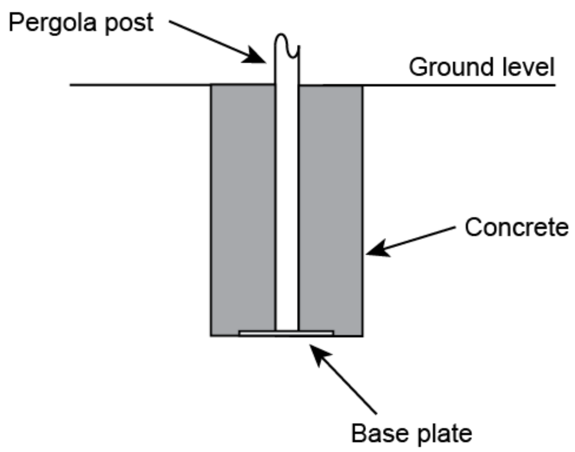
Mass of patio tube = ____________________

(c) The sloping roof of the pergola is to be covered with polycarbonate sheeting. Calculate the required area to be covered in square metres.

(2 marks)

Mass of patio tube = ____________________

(d) The posts of the pergola will have a flat plate welded across their bottom ends to provide a secure anchor when embedded in concrete. This is shown as follows:



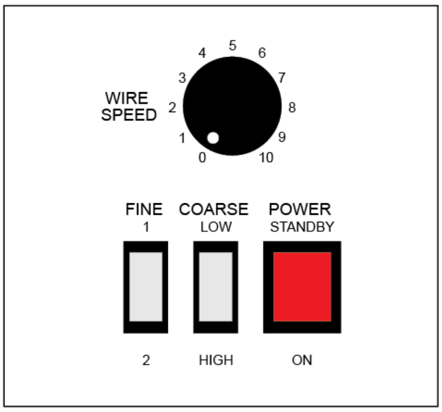
If the holes dug for the footings are 350 mm square and 1.0 m deep, calculate the volume of concrete required to fill all the holes after the posts of the pergola have been inserted.

Note: No need to allow for the plates welded on the bottom of the posts.

(4 marks)

Volume of concrete required = ________________________________

(e) To join the parts of the pergola a welding machine called a MIG welder will be used. Two images of the front panel are shown below:



Control switches

SETTING SELECTION GUIDE			PLATE THICKNESS MILD STEEL					
SHIELDING GAS	WELDING WIRE	CONTROL SETTINGS	0.8mm	1mm	1.6mm	2mm	3mm	5mm
Argon 5-25% CO_2 1-3% CO_2	0.6mm SOLID	COARSE FINE WIRESPEED	Low 1 7.5	Low 1 7.5	Low 2 9	High 1 10		
	0.8mm SOLID	COARSE FINE WIRESPEED			Low 1 5.5	Low 2 6	High 1 8.5	High 2 8.5
Gasless Wire	0.8mm CORED	COARSE FINE WIRESPEED			Low 1 5.5	Low 2 6.5	High 1 7.5	High 2 8.5
	0.9mm CORED	COARSE FINE WIRESPEED			Low 1 3	Low 2 5	High 1 6.5	High 2 8

Settings selection panel

If 0.8 mm cored wire is used, what control settings are required?

(2 marks)

Coarse switch = ______________________

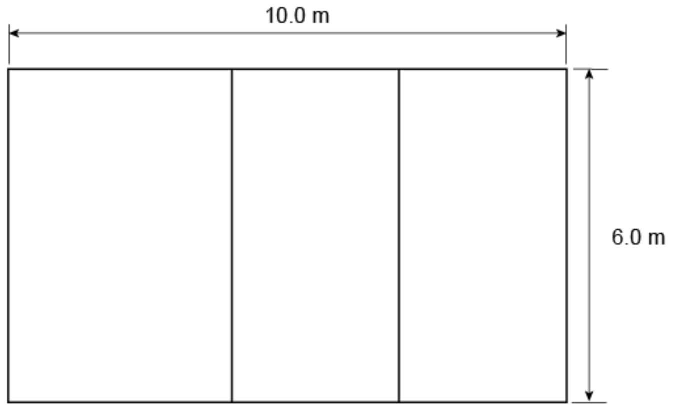
Fine switch = ________________________

Wire speed = ________________________

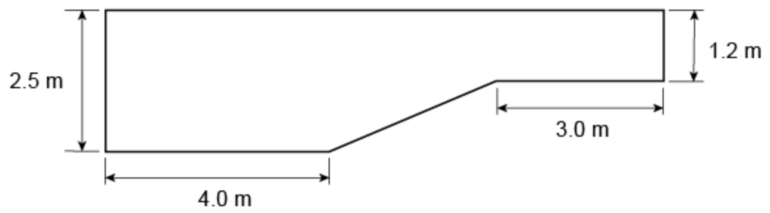
Question 3* **(20 marks)**

* Sourced from 2009 WACE

A manufacturer of fibreglass below-ground swimming pools has asked you to do some preliminary calculations for a new design of pool that it is considering. It has provided you with the sketch shown below. The pool is rectangular in plan view, 10 m x 6 m, has a 3 m long shallow end 1.2 m deep, a 4 m long deeper end 2.5 m deep, joined by a 3 m transition section.



Plan



Front elevation

(a) Calculate the mass of the water in the pool, assuming that it is filled completely.

(5 marks)

Mass of water = ________________________________

(b) The fibreglass supplier recommends constructing the pool with eight layers of fibreglass. Show by calculation that the total area of fibreglass required to do the job will be close to 977 m^2. All working must be clearly shown.

(5 marks)

(c) The fibreglass is supplied on a 6 m wide roll. Allowing a 15% excess for overlapping at its edges, calculate the length of the roll required to manufacture one pool.

(3 marks)

Length of roll required = ____________________________________

(d) The density of the finished fibreglass (with its resin system) is 2000 kg m^{-3}. Assuming a finished thickness of the fibreglass of 10 mm, calculate the mass of a finished pool (empty of water).

(2 marks)

____

____

____

Mass of pool (empty) = ______________________________

Question 4* **(15 marks)**

* Sourced from 2010 WACE

The two perspective views on the next page show the same sculpture, which is to be manufactured from concrete.

(a) Sketch and label the following orthographic views of this sculpture correctly related to each other using a standard orthographic projection on the graph page provided.

(8 marks)

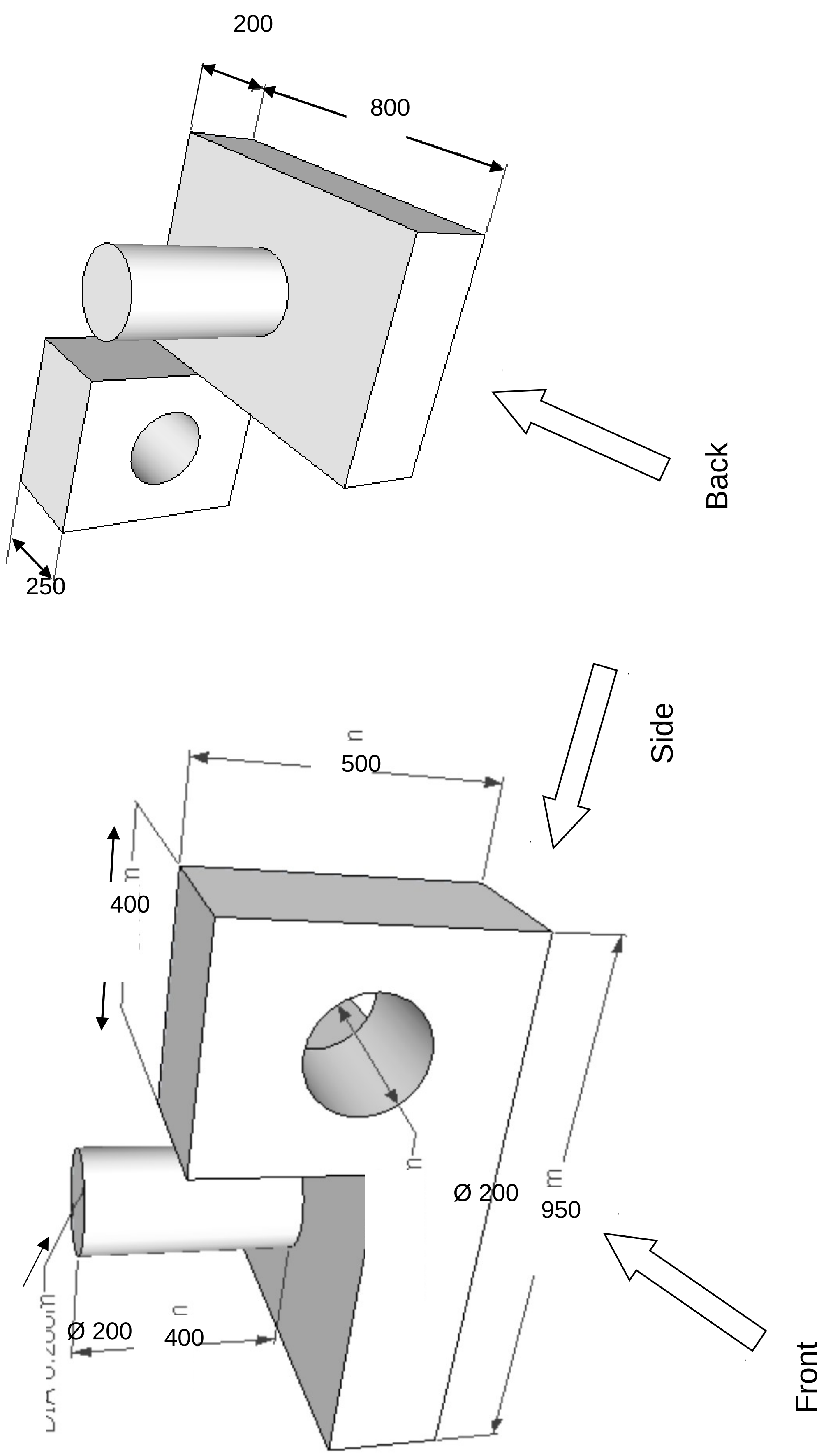
The following are required:

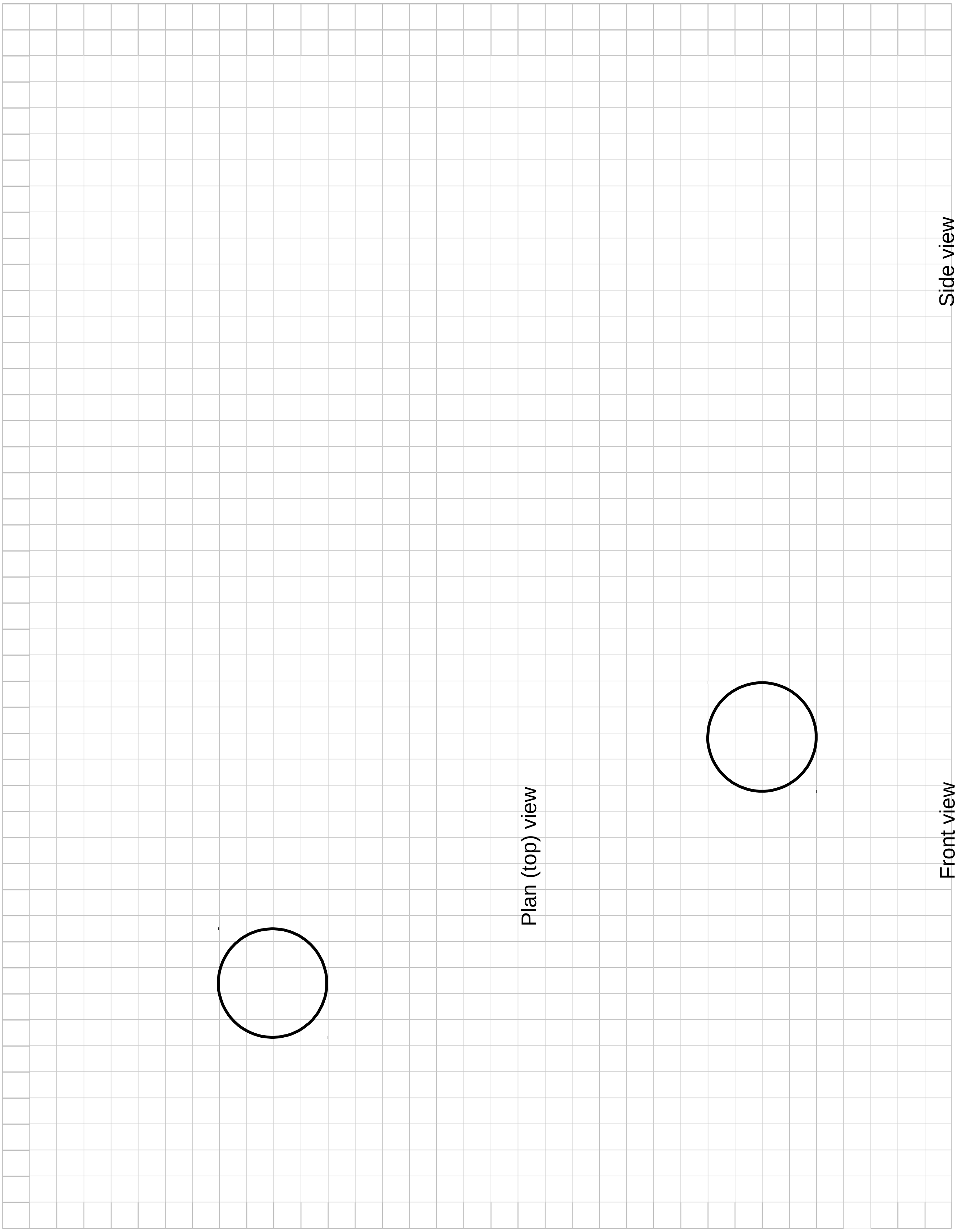
(i) a plan (top) view, looking down from the top (circular feature given),

(ii) a front view in the direction marked (circular feature given)

(iii) a side view in the direction marked, and

(iv) the correct relationship between views.


200
800
250
Back
Side
500
400
Ø 200
950
Ø 200
400
Front



- *Circular elements are located at the centres of their respective block parts.*

...lume of concrete, in cubic metres (m^3), required to make this

- *All outlines, hidden detail and centrelines must be shown.*

(5 marks)

Side view

- *Dimensions need **not** be shown.*
- *Each square on the graph page represents*

Volume of concrete required = ______________________

(c) Calculate the mass of concrete required to make this sculpture. Refer to page 5 of the Data book for more information.

(2 marks)

Mass of concrete required = ______________________

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Question 5* **(15 marks)**

* Sourced from 2011 WACE

There are 500 galvanised steel brackets to be made for a job. The bracket is shown in the partially completed orthographic and isometric drawings on the next page. The drawing grid on the page is 5 mm by 5 mm.

(a) Complete the orthographic drawing on the **next page** by finishing the Front view and adding the Top and Right Side views, ensuring the:

(i) top, front and right side views are complete. [5 marks]

(ii) views are correctly related to each other. [4 marks]

(iii) completed drawing is neat and tidy. [2 marks]

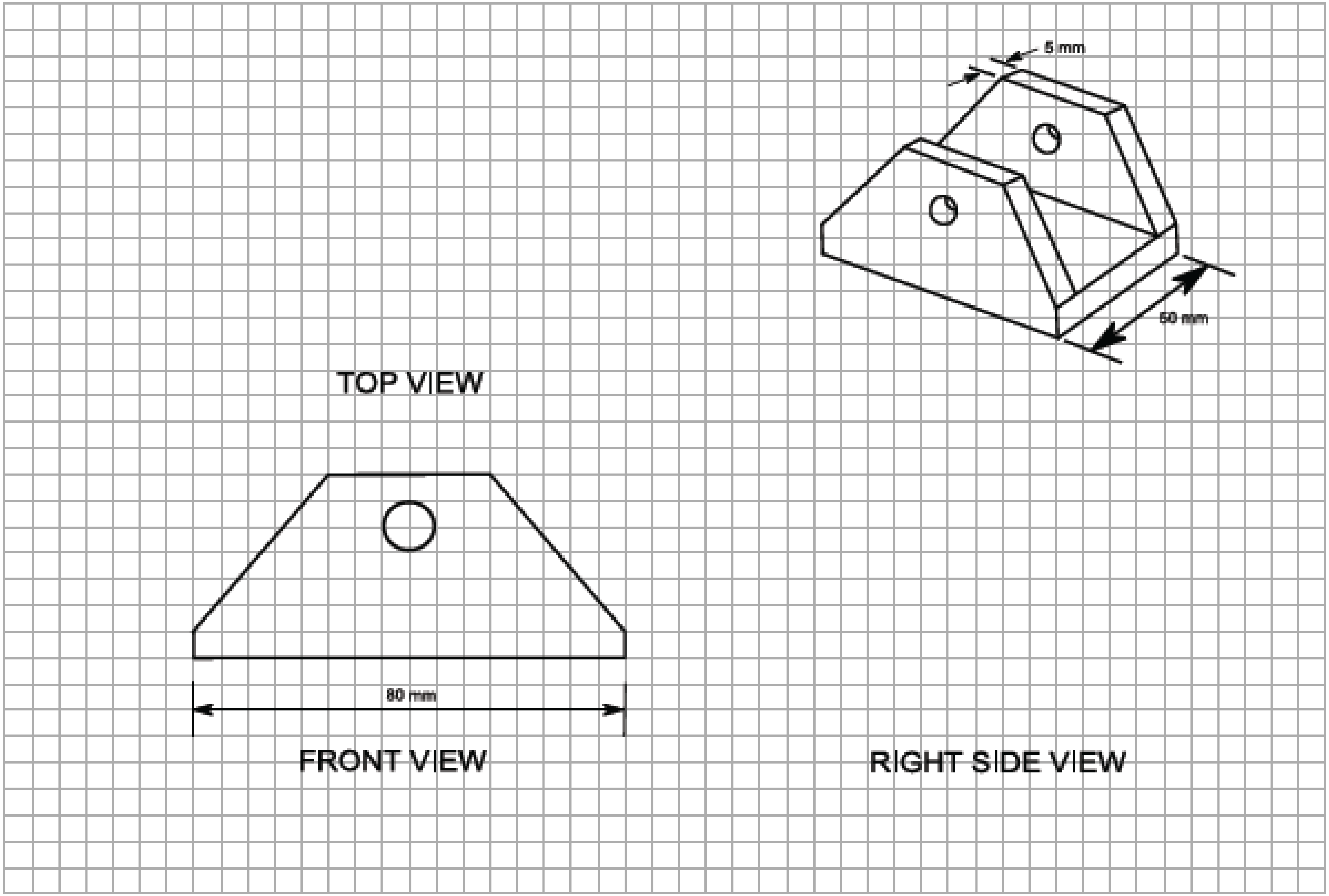
(11 marks)

(b) The surface area of each bracket is 0.0152 m^2 and each bracket requires two coats of galvanised paint with a coverage of 20 m^2 per litre for each coat.

Calculate the volume of paint in litres required to paint all of the brackets, assuming no wastage.

(4 marks)

Volume of paint required (litres) = ______________

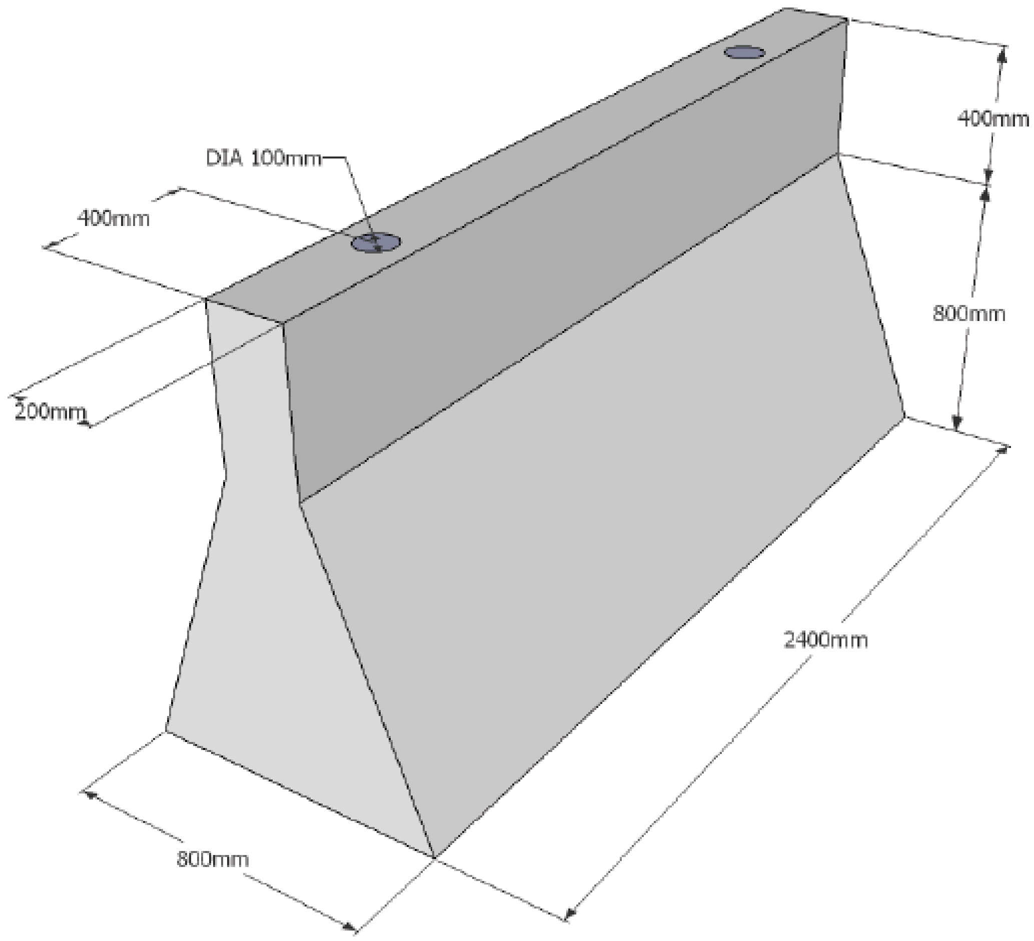


5 mm
50 mm
TOP VIEW
80 mm
FRONT VIEW
RIGHT SIDE VIEW

Question 6* **(15 marks)**

* Sourced from 2012 WACE

The following diagram shows a pictorial view of a traffic barrier module, of the type often seen near roadwork to control the flow of traffic. These traffic barriers are made of tough impact-resistant plastic and can be filled with water.



The module has a mass of 56 kg when empty. There are two 100 mm diameter holes in the top of the barrier to allow water to be added. The water can be emptied from a drain valve located near the base of the module (not shown in this drawing).

(a) Calculate the total mass of the module when it is filled with water. The thickness of the walls can be ignored. Show all workings.

(6 marks)

Total mass = ________________

(b) On the grid provided below create a top view of the barrier module. Add all dimensions that can be shown on a top view. The major divisions of the grid represent 200 mm by 200 mm with each grid subdivided into 40 mm by 40 mm squares.

(5 marks)

(c) Provide an explanation as to why it is useful to have a barrier module that can be filled with water.

(2 marks)

(d) The water is added to the barrier module from a water tanker truck that has a 100 mm diameter hose that just fits into one of the holes in the top of the module. Explain why a second hole in the top is necessary.

(2 marks)

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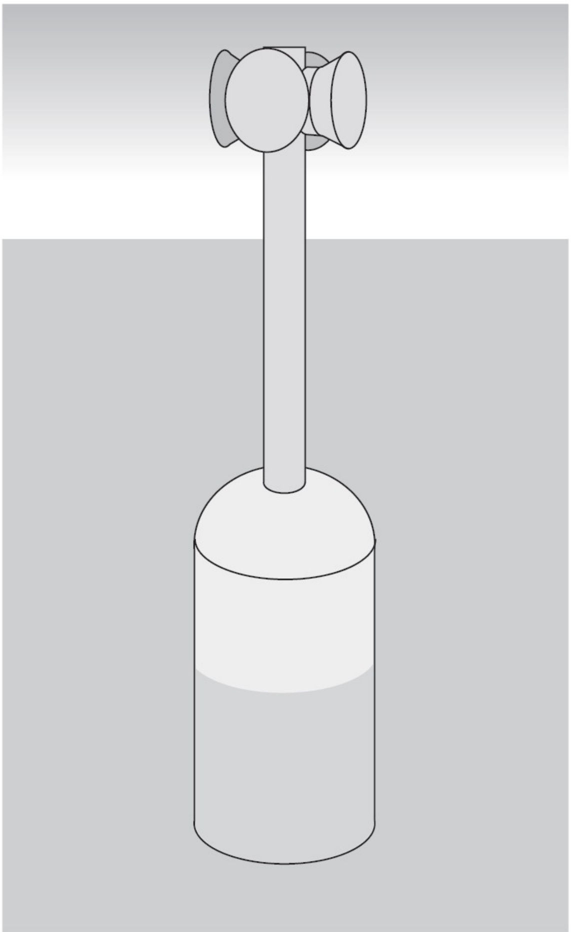
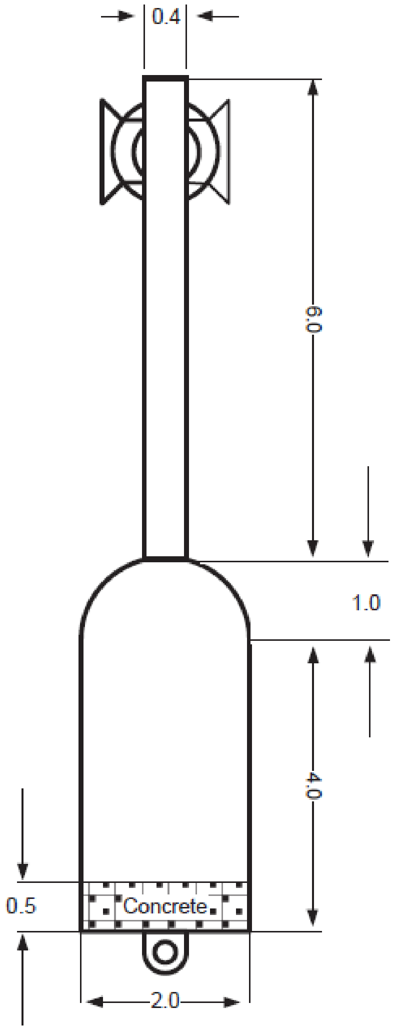
Question 7* **(15 marks)**

* Sourced from 2013 WACE and slightly modified.

The following drawings show a marine buoy of the type that is often used to mark navigation channels in the ocean. The buoy has a cylindrical body section with a hemispherical cap. It is topped by a cylindrical post on which four navigation lights are mounted. The buoy is held in position by an anchor chain connected to the lug at the bottom. To ensure that the buoy floats in an upright position it is partially filled with concrete.





Cross Section

The buoy is made from 8 mm thick stainless steel. Each of the navigation lights (and the associated electronics) weighs 300 kg. The anchoring lug weights 20 kg. All dimensions are in metres.

(a) Using calculations, demonstrate that close to 42.2 m^2 of stainless steel is used to construct the buoy and its post. The post is sealed at the top to keep out water and its base is fitted directly to the unbroken surface of the hemisphere. The lug and the lights can be ignored for this calculation. Show all workings.

(6 marks)

(b) Using the surface area from (a) show that the total weight of the buoy, including all its parts, is approximately 7500 kg. Show all workings.

(5 marks)

(c) If the buoy was floating in calm water, how far would it sink into the water? Use the fact that the buoy will displace an amount of water equal to its own weight i.e. Archimedes' principle. Show all workings.

(4 marks)

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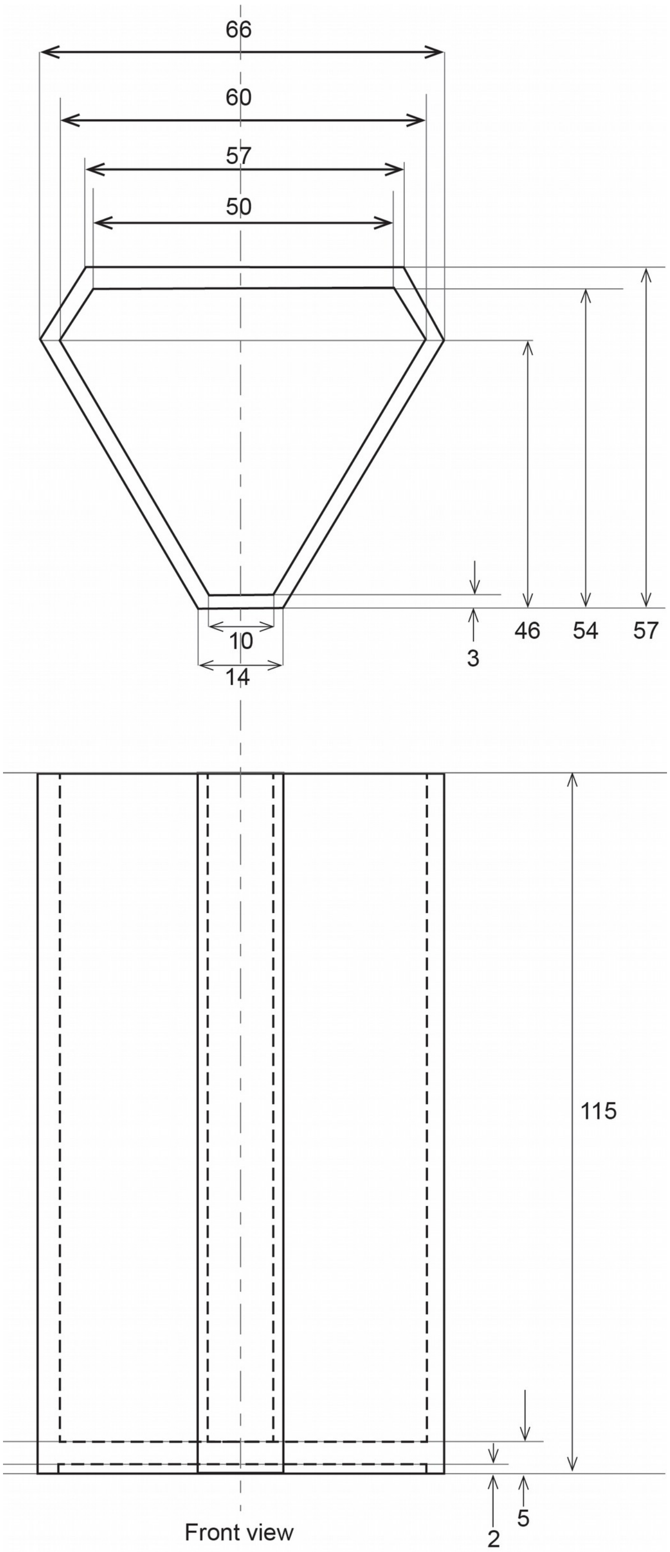
Question 8* **(21 marks)**

* Sourced from 2014 WACE

The orthographic drawing given below shows the top and front views of an aluminium coffee cup. All dimensions shown are in millimetres. The scale of the drawing is 80% full size.

(a) Add a right side view of the coffee cup. Show all dimensions and hidden detail.

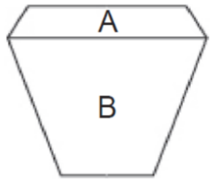
(6 marks)



(b) Use the dimensions from the drawing to calculate the maximum volume of liquid capable of being held by the coffee cup. Show **all** workings.

(6 marks)

Hint: you can work out the area of the base by dividing the base into sections, such as that show in this diagram:



(c) Calculate the volume of aluminium in the coffee cup. Show **all** workings.

(6 marks)

(d) Assuming that the density of coffee is the same as the density of pure water, calculate the total mass of the aluminium coffee cup when it contains the maximum volume of coffee. Show **all** workings.

(3 marks)

More questions

WACE 2011 multiple-choice questions 2 and 6.

WACE 2013 multiple-choice questions 2, 4 and 9.

WACE 2014 multiple-choice questions 1, 2 and 3.

WACE 2015 multiple-choice question 10; question 13 (a)(i) – (v) and (b)(i) and (ii).

WACE 2016 multiple-choice questions 6 and 10; question 11 (a), (c), (d), (e) and (f); question 12 (a); question 13 (b)(i), (b)(ii); and question 14 (c), (d), (e)(i), (e)(ii) and (f).

WACE 2017 multiple-choice questions 6 and 10; question 11 (a), (c) and (d); question 12 (a) and (c); and question 13 (b).

4. Materials

Classification of materials

1. Metal (pure)

   Definition: A substance that is usually solid at room temperature, has a lustrous surface when freshly cut, usually malleable and ductile, and a good conductor of heat and electricity.

   Examples:____

2. Alloy

   Definition: A compound (sometimes a mixture) of two or more pure metals that form a new metal or a compound of metal(s) with non-metal(s)

   a. Ferrous alloys (iron based)

      Examples:____

   b. Non-ferrous alloys

      Examples:____

3. Polymer

   Definition: Non-metallic material in which the molecular structure consists of long-chain molecules (polymers) formed by the combination of many simple molecules (mers).

   Examples –

   Thermoplastic:____

____

____

Thermoset:____

____

Elastomer:____

____

____

____

4. Composite

Definition: A combination of two or more materials exhibiting properties distinctly different to those of the individual materials.

Examples:____

____

____

____

Properties

For each of the properties that follow below give an example of a situation or application where the property is of great importance. Whenever possible cite the material that would be used:

1. Density

   Definition: Mass per unit volume of a material.

   Example:____

2. Elasticity

   Definition: Ability of a material to return to its original dimensions after being subjected to stress that caused it to deform.

   Example:____

3. Plasticity

   Definition: Ability of a material to undergo permanent deformation without rupture occurring.

   Example:____

4. Strength (Tensile)

   Definition: Ability of a material to withstand stress that pulls on a material.

   Example:____

5. Strength (Compressive)

Definition: Ability of a material to withstand stress that squeezes a material.

Example:

6. Stiffness

Definition: Ability of a material to resist deformation under load.

Example:

7. Toughness

Definition: Ability of a material to absorb energy without failing.

Example:

8. Hardness (not in syllabus but useful to know)

Definition: Ability of a material to resist abrasion, scratching, indentation or penetration.

Example: ____________________

____

____

9. Ductility

Definition: Ability of a material to be plastically deformed by predominately tensile stresses.

Example: ____________________

____

____

10. Malleability

Definition: Ability of a material to be plastically deformed by predominately compressive stresses.

Example: ____________________

____

____

11. Conductivity (Electrical)

Definition: Ability of a material to conduct electricity.

Example: ____________________

____

____

12. Conductivity (Thermal)

Definition: Ability of a material to conduct heat.

Example:____

13. Corrosion resistance

Definition: Ability of a material to resist destruction by chemical or electrochemical attack.

Example:____

More questions

WACE 2013 multiple-choice questions 1 and 8; and question 12 (b).

WACE 2014 multiple-choice questions 5, 6 and 7; and question 11 (b).

WACE 2015 multiple-choice question 5; and question 12 (a)(i) – (v), (b)(i) and (ii), (c)(i) and (ii); and 13 (a)(vi).

WACE 2016 multiple-choice question 3; question 12 (b), (c), (d); and (e), question 13 (c) and question 14 (a).

WACE 2017 multiple-choice question 9; question 11 (i) and (j).

5. Life cycle analysis

The stages of the life cycle of an engineered product

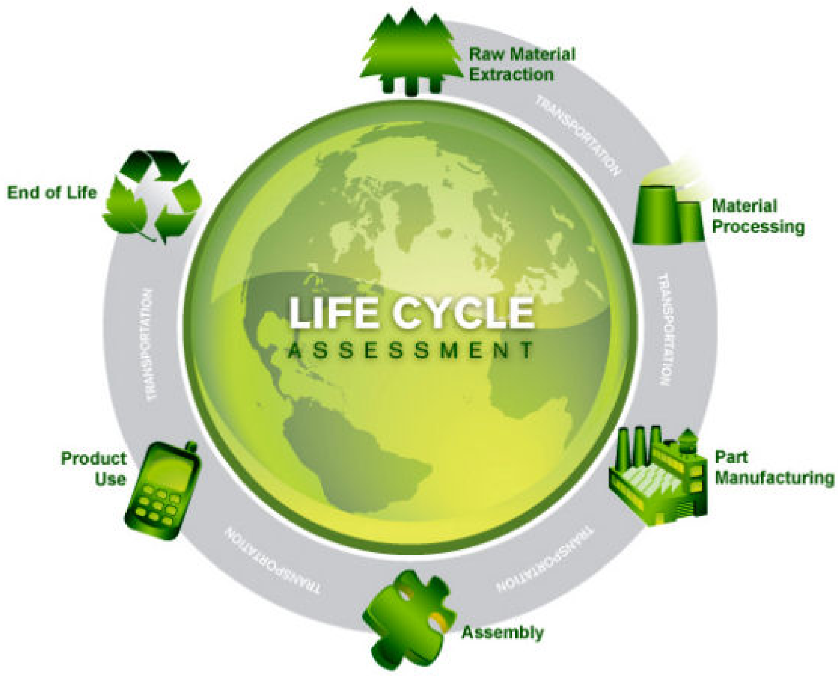
- materials acquisition
- processing materials
- manufacture
- packaging
- transport
- maintenance/operation
- reuse/recycle/disposal

Engineering in society

Identify and discuss impacts for society, business and the environment that occur during the life cycle of engineered products.

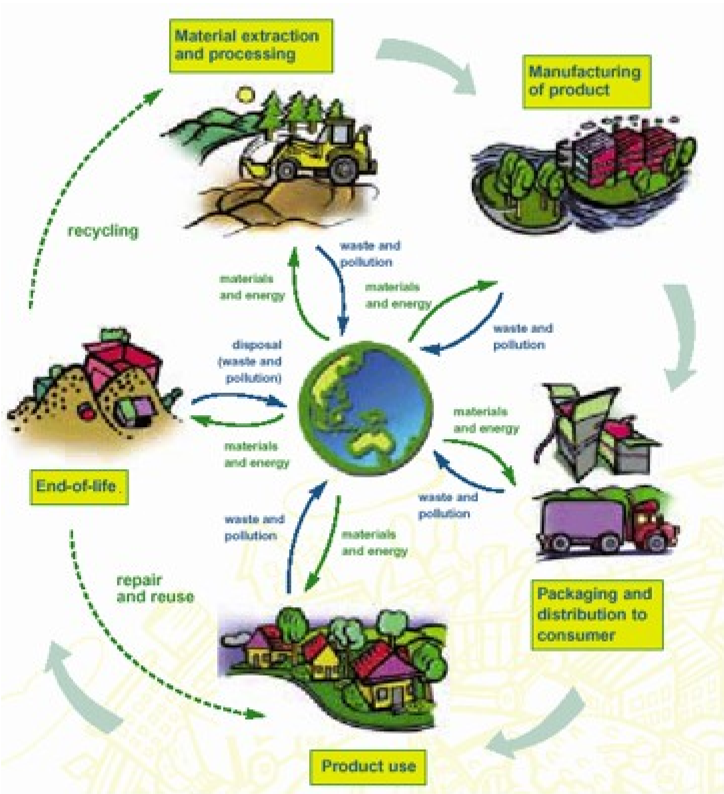
Definitions:

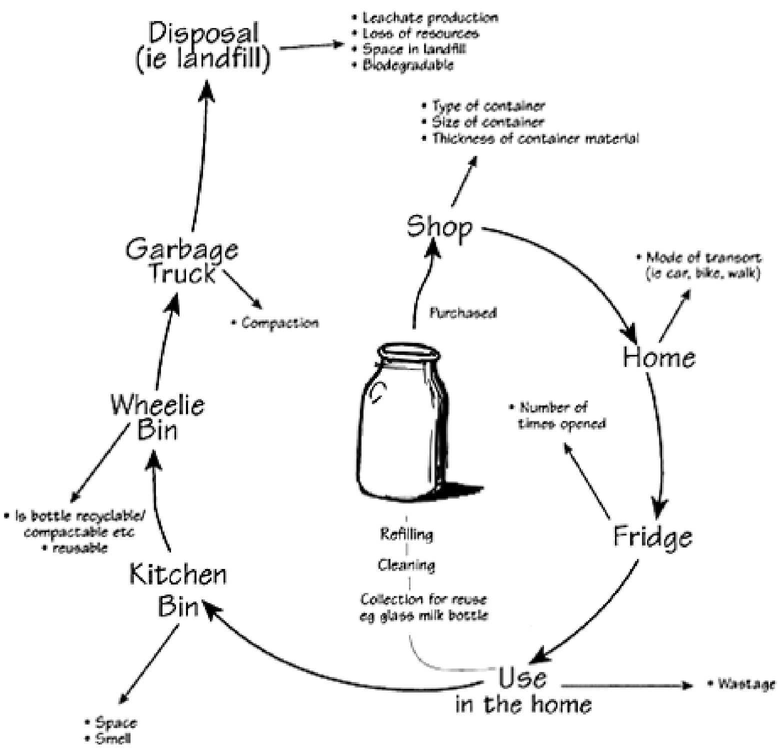
1. LCA is the detailed analysis that gives you the information you need to make the most environmentally friendly decisions throughout product design. The analysis looks at a product's entire life, which encompasses ore extraction, material production, manufacturing, product use, end-of-life disposal, and all the transportation that occurs between these stages.



www.solidworks.com/sustainability

2. The assessment of the effect a product has on the environment from the initial concept to disposal





http://www.ruthtrumpold.id.au/designtech/pmwiki.php?n=Main.LifeCycleAnalysis

3. Life Cycle Assessment (LCA) is a scientific method used to quantify, understand and evaluate the environmental impacts of a product or service over the full life cycle; from cradle to grave. LCA can be applied to any product or service; from major infrastructure projects to consumer goods.

Royal Melbourne Institute of Technology (RMIT)

4. Life-cycle assessment (LCA, also known as life-cycle analysis, ecobalance, and cradle-to-grave analysis)[1] is a technique to assess environmental impacts associated with all the stages of a product's life from-cradle-to-grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling). LCAs can help avoid a narrow outlook on environmental concerns by:
   - Compiling an inventory of relevant energy and material inputs and environmental releases;
   - Evaluating the potential impacts associated with identified inputs and releases;
   - Interpreting the results to help make a more informed decision.[2]

http://en.wikipedia.org/wiki/Life-cycle_assessment

5. Life cycle assessment (LCA) is a method of analysing the environmental impacts of a process, product or activity along its life cycle, for example from 'the cradle to the grave'.
   The objective of most LCA studies is to help food producers, manufacturers, mining companies and product producers examine inputs (such as resources, materials and electricity) and outputs (such as waste) and the impacts of these to improve efficiencies and identify where better environmental performance can be achieved.
   The LCA approach forms the basis for a range of well-known 'footprint' assessments including 'carbon footprinting'.

http://www.csiro.au/Organisation-Structure/Flagships/Sustainable-Agriculture-Flagship/Life-cycle-assessment.aspx

Questions

WACE 2009 multiple-choice question 8.

WACE 2011 multiple-choice question 7.

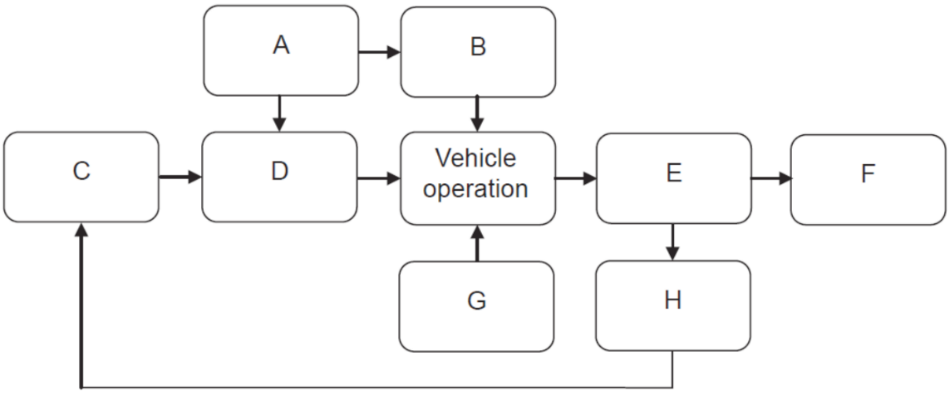
WACE 2012 multiple-choice question 10 and question 13 (d).

WACE 2013 multiple-choice question 13 (e):

Complete the simplified life cycle diagram of a vehicle as shown below by matching the following labels (1-8) to the boxes (A-H).

(4 marks)

Label 1 – Recycling
Label 2 – Raw materials
Label 3 – Waste products
Label 4 – Fuel production
Label 5 – Landfill and emissions
Label 6 – Vehicle production
Label 7 – Energy sources
Label 8 – Vehicle maintenance



Use the above diagram (with pencil and eraser) to develop your answer and once complete show your answers below by writing the label number next to each box label.

Box A: ______________
Box B: ______________
Box C: ______________
Box D: ______________
Box E: ______________
Box F: ______________
Box G: ______________
Box H: ______________

WACE 2014 multiple-choice question 7.

WACE 2015 multiple-choice questions 6 and 7.

WACE 2017 multiple-choice question 2.