OCR
Oxford Cambridge and RSA

Level 3 Cambridge Technical in Engineering
05822/05823/05824/05825/05873

Unit 2: Science for engineering

Friday 18 May 2018 – Morning

Duration: 1 hour 30 minutes

C302/1806

C302/1806

You must have:
- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- a ruler (cm/mm)
- a protractor
- a scientific calculator

First Name		Last Name	

Centre Number						Candidate Number				

Date of Birth	D	D	M	M	Y	Y	Y	Y

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- The acceleration due to gravity is denoted by g m s^{-2}. Unless otherwise instructed, when a numerical value is needed, use g = 9.8.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- An answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
- Final answers should be given to a degree of accuracy appropriate to the context.
- This document consists of **16** pages.

FOR EXAMINER USE ONLY	
Question No	**Mark**
1	/10
2	/10
3	/10
4	/10
5	/11
6	/9
Total	**/60**

Answer **all** the questions.

1 **(a)** Which of the following units is a correct unit of force? Put a ring around the correct response.

kg m s^{-1} kg m s^{-2} kg m^2 s^{-2} kg m^2 s^{-1}

[1]

(b) Convert the following measurements to the given units.

- 5 m = ……..…… µm
- 10 cm^2 = …… m^2
- 100 litre = …….. mm^3

[3]

(c) For a standard deviation of $\sigma = 0.45$ and sample size $N = 15$ calculate the standard error of the mean. Use the equation standard error of the mean = $\sigma/(\sqrt{N})$.

Standard error of the mean = …… **[1]**

(d) Explain what is meant by the term 'calibration' and why it is important in measuring.

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.....

.....

..... **[3]**

(e) If the true length of a beam is 150 mm and the measured value is 151 mm calculate the relative error and absolute correction.

Relative error = ……..… **[1]**

Absolute correction = ……. mm **[1]**

2 **(a)** A 75 kg driver is travelling in a car with mass 1300 kg.

Fig. 1 shows how the velocity of the car changes as it stops at traffic lights.

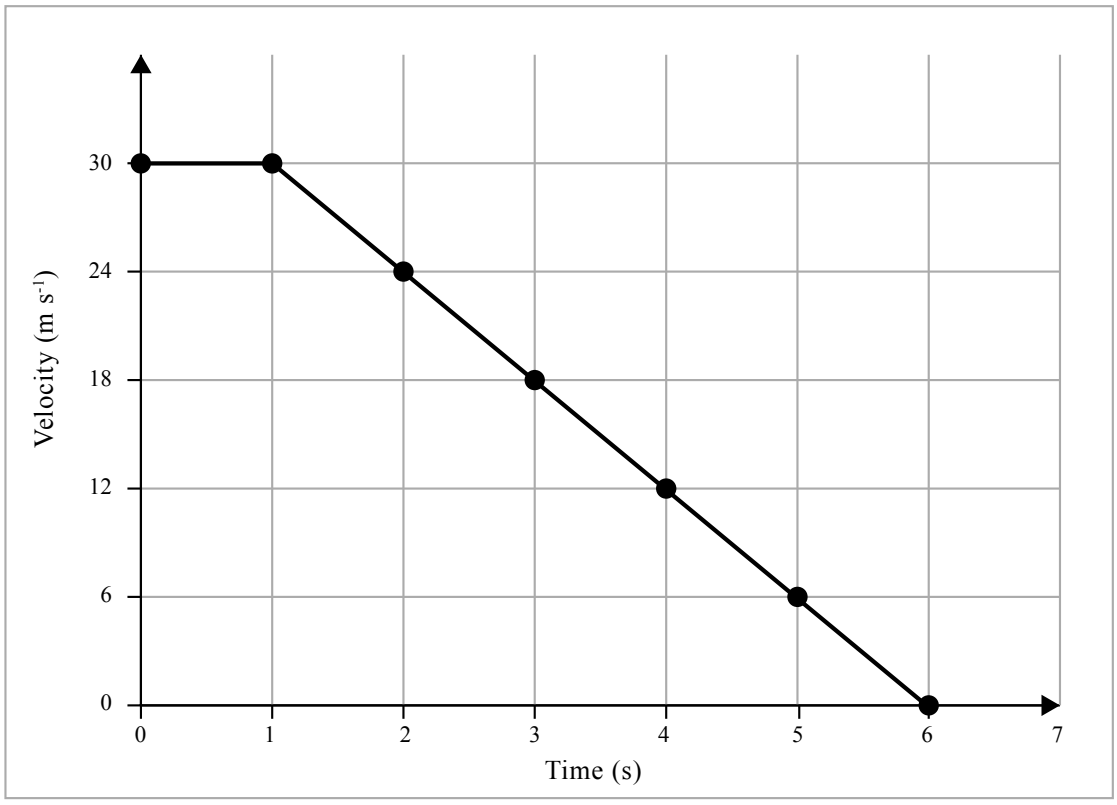

Fig. 1

Calculate

(i) the deceleration of the vehicle whilst it is braking. Indicate the units used in your answer.

Deceleration = …… **[2]**

(ii) the force acting on the driver due to the deceleration in part (i).

Force = …….. N **[1]**

(b) The same car and driver travel along a straight road at 100 km h^{-1}. The driver applies the brakes and comes to a stop in 38 m.

Calculate

(i) the initial kinetic energy,

Kinetic energy = …… J **[2]**

(ii) the average total braking force.

Average braking force = …… N **[2]**

(c) Fig. 2 shows an aerial view of the horizontal forces acting on the car as it goes around a bend.

Determine the value of the resultant horizontal force acting on the car and its direction relative to F_1.

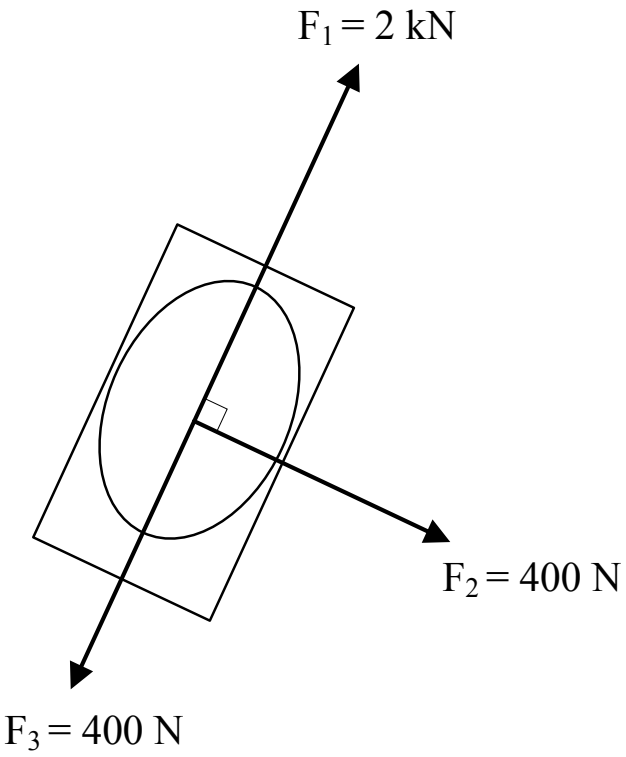

Fig. 2

Resultant force = ... N

Direction = ...

[3]

3 **(a)** A resistor is connected to a charged capacitor. Initial current flowing through the resistor is 5 mA and it drops to 0.68 mA after 2 seconds.

(i) On the axes shown in Fig. 3 sketch the graph to show how the current through the resistor changes with time over the first 3 seconds.

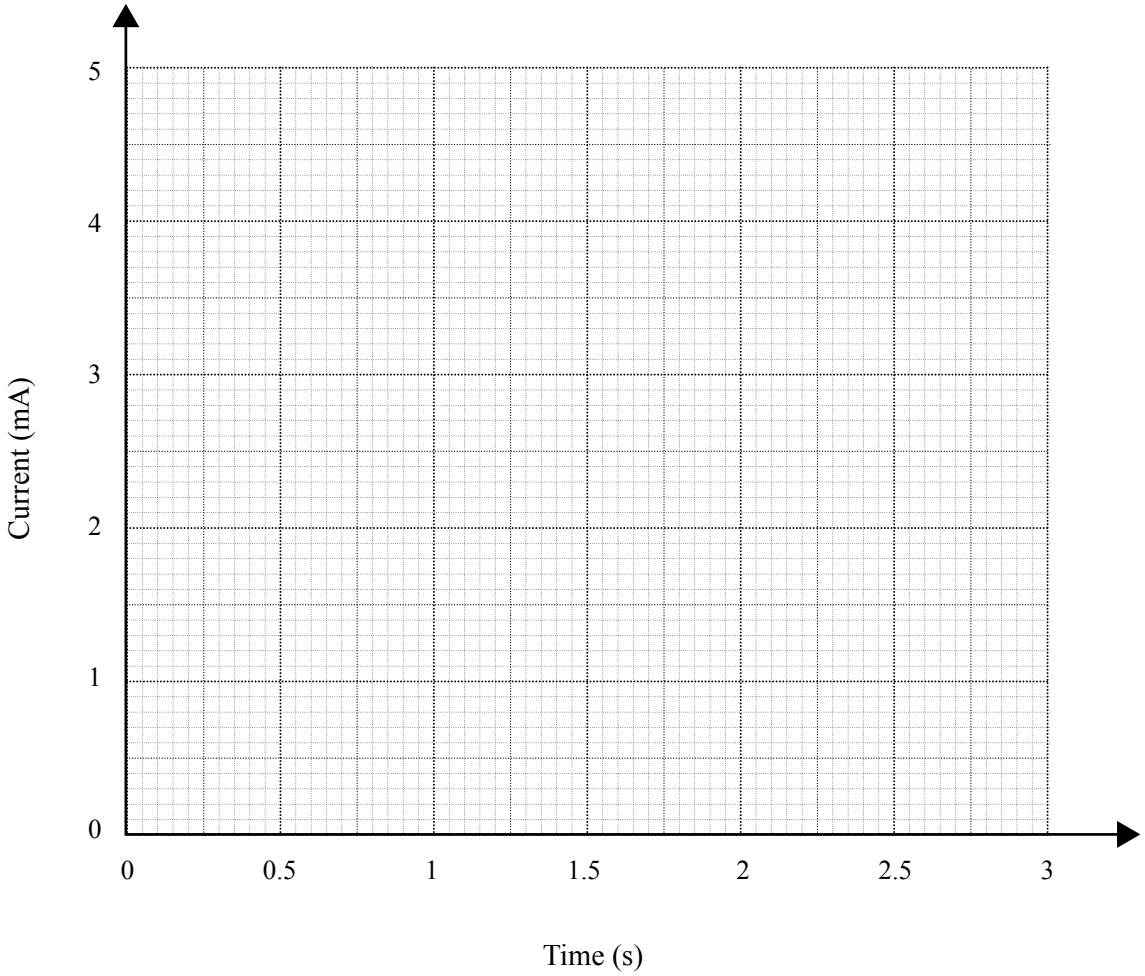

Fig. 3

[2]

(ii) Explain how the graph drawn in Fig. 3 could be used to find an approximate value of the time constant for the discharge of the capacitor.

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.....

..... **[2]**

(b) A partially charged capacitor is additionally charged with 2 mA for 5 seconds. The internal resistance of the capacitor is 200 MΩ. The final voltage over the capacitor is 40 V.

Calculate

(i) how much charge has been added to the capacitor,

Charge added = ……..C **[1]**

(ii) the electrical energy added to the capacitor.

Indicate the units used in your answer.

Energy = ……. **[2]**

(c) A DC electric motor draws a 2 A current from a 300 V supply. The efficiency of the motor is 80%.

Calculate

(i) the output power of the motor,

Output power = …….. W **[2]**

(ii) the energy supplied to the motor during 1 minute.

Energy supplied = ……..J **[1]**

4 **(a)** Fig. 4 shows the stress-strain graphs for two materials.

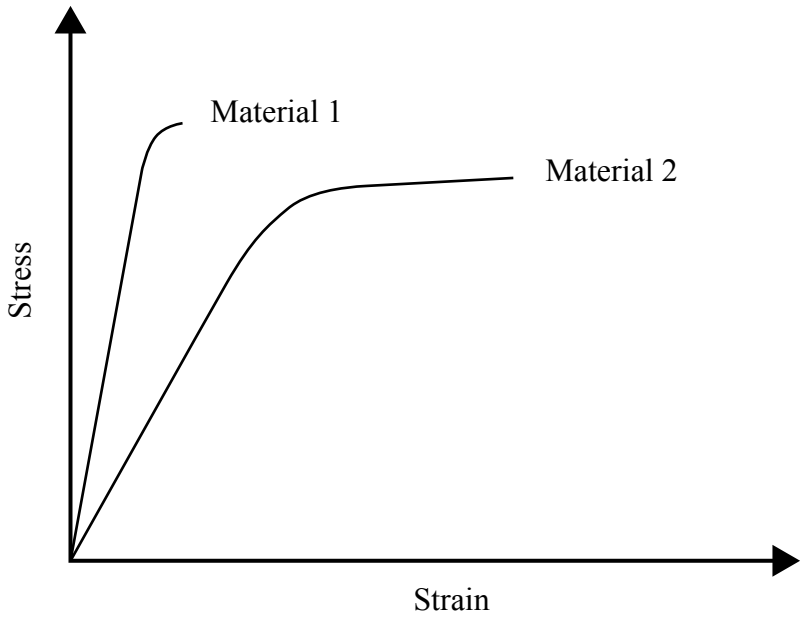

Fig. 4

State and explain which material, 1 or 2, is

(i) stiffer,

.....

.....

..... **[2]**

(ii) stronger,

.....

.....

..... **[2]**

(iii) tougher.

.....

.....

..... **[2]**

(b) The table below shows some material properties for steel and an aluminium alloy.

Material property	**Steel**	**Aluminium alloy**
Young's Modulus *E* (GPa)	201	69
Yield Strength (MPa)	450	260

A tie bar of length 1 m and cross section area 40 mm^2 needs to support a 10 kN load without elongating by more than 2 mm.

Explain which material is more suitable. Support your choice with calculation.

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..... **[4]**

5 **(a)** Fig. 5 shows a hydraulic lift designed to displace a 700 N load by 15 cm on a 350×10^{-4} m^2 plate.

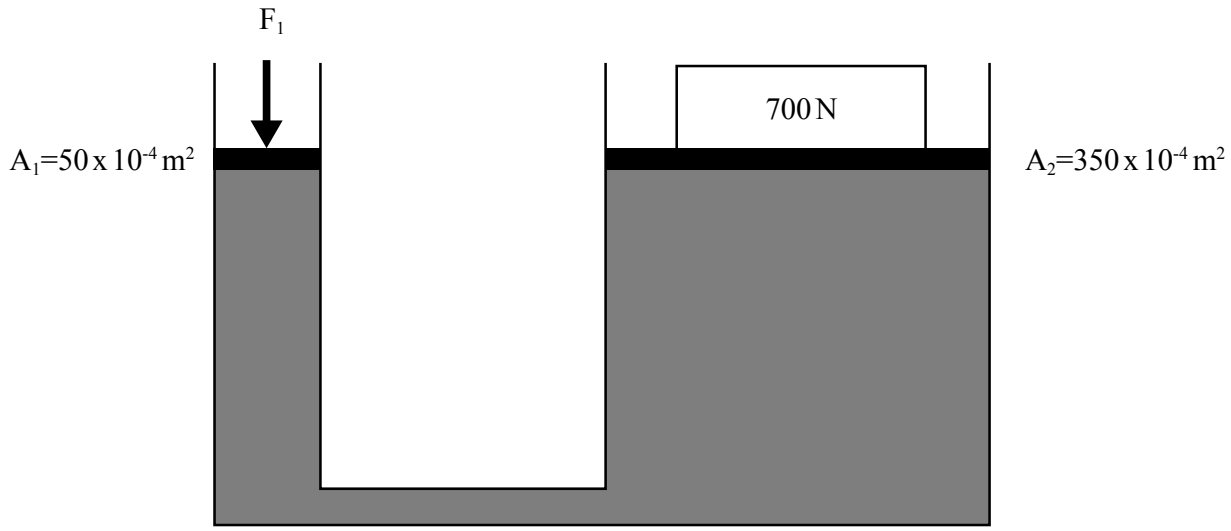

Fig. 5

Calculate

(i) the pressure exerted by the working fluid on plate A_2,

Pressure = …… Pa **[2]**

(ii) the force F_1 exerted on a 50×10^{-4} m^2 plate A_1 required to elevate the 700 N load,

Force = …… N **[1]**

(iii) the vertical displacement of plate A_1 required to achieve a 15 cm displacement of the 700 N load.

Vertical displacement = …….. cm **[2]**

(b) Fig. 6 shows a communicating vessel which is initially separated by a baffle.

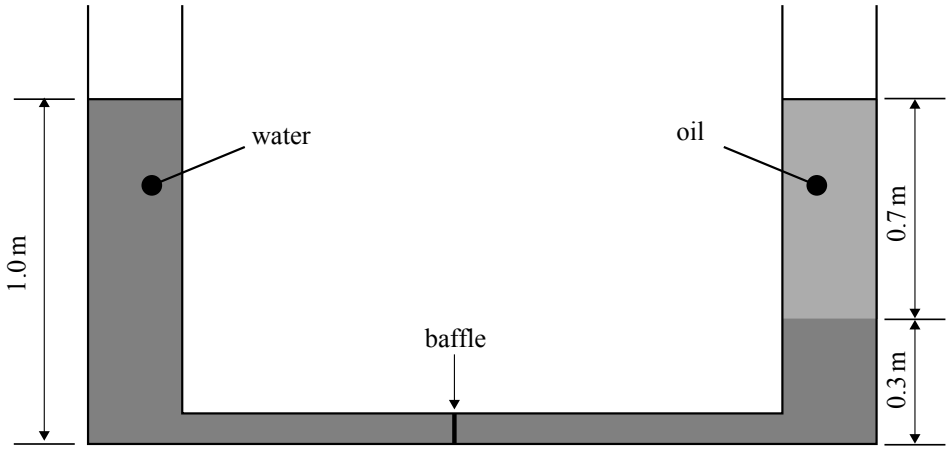

Fig. 6

The column on the left contains water with height $h_1 = 1\,\text{m}$.

The column on the right contains water and oil.

The height of the water column $h_2 = 0.3\,\text{m}$ and the height of the oil column $h_3 = 0.7\,\text{m}$.

Density of water $\rho_w = 1000\,\text{kg m}^{-3}$

Density of oil $\rho_o = 800\,\text{kg m}^{-3}$

Calculate

(i) the hydrostatic pressure at the bottom of the left side of the vessel,

Pressure = ... Pa **[1]**

(ii) the height of the water column on the left side of the vessel once the baffle has been removed. Indicate the units used in your answer.

Height = ... **[5]**

6 Fig. 7 shows a hydraulic turbine-generator unit installed in a water dam which is used to generate electricity.

Water enters and leaves the turbine at 2.5 m s^{-1} through pipes of constant diameter d = 2 m.

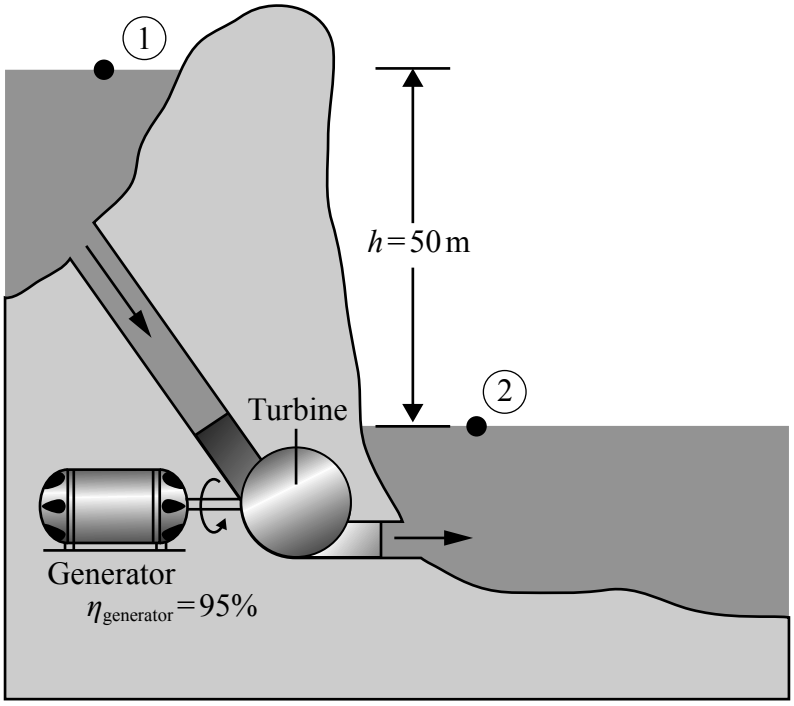

Fig. 7

The height at the surface of the upper reservoir (point 1) is 50 m above the surface of water in the lower reservoir (point 2).

The efficiency of the generator = 95 % and it supplies 3300 kW.

Density of water ρ_w = 1000 kg m^{-3}

The mass of water entering the turbine each second is known as the mass flow rate.

Calculate

(i) the mass flow rate of water,

Mass flow rate = …….. kg s^{-1} **[2]**

(ii) the change in gravitational potential energy per unit mass of water between points 1 and 2,

Change in energy per unit mass = ……..…….. J kg^{-1} **[2]**

(iii) the power supplied to the turbine by the fluid,

Power supplied = …….. W **[2]**

(iv) the efficiency of the turbine.

Efficiency of turbine = ……. **[3]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown – for example 3(a)(ii) or 4(b).

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