Name of the Student:_____
Max. Marks : 26 Marks **Time : 26 Minutes**

Q1.

(a) Which row in the table below shows

- **Process 1** in which work done is zero, and
- **Process 2** in which the change in internal energy is zero?

Tick (✓) **one** box.

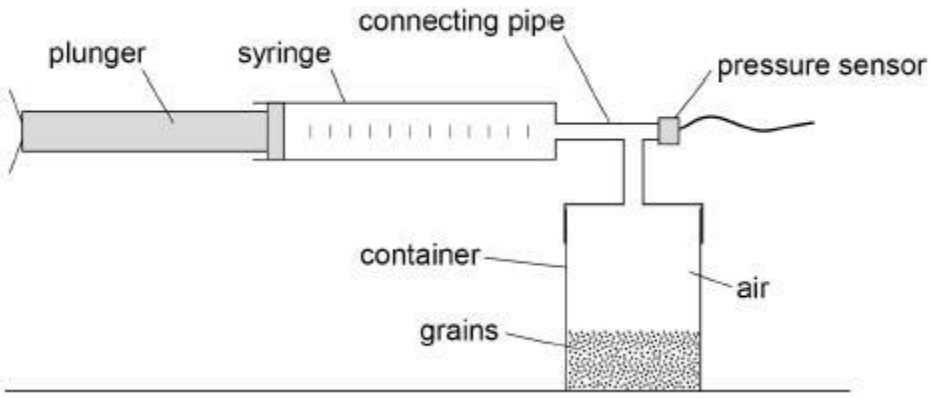
Process 1	Process 2	
constant pressure	isothermal	☐
constant volume	adiabatic	☐
constant pressure	adiabatic	☐
constant volume	isothermal	☐

(1)

(b) When irregular particles are packed, air gaps are left between the particles.
The true volume of a quantity of irregular particles must be determined using a method that does not include the volume of the air spaces between them.

The apparatus shown in **Figure 1** is used by an agricultural engineer to measure the true volume of some grains.

Figure 1



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The volume of air in the syringe is 1.00×10^{-4} m^3.
The volume of the **empty** container and connecting pipe is 2.80×10^{-4} m^3.
Grains of total true volume V are now placed in the container and the lid is screwed on.
The pressure inside both the syringe and the container is 1.01×10^5 Pa.
The plunger is slowly pushed fully into the cylinder of the syringe, compressing the air isothermally.
The pressure increases to 1.83×10^5 Pa.

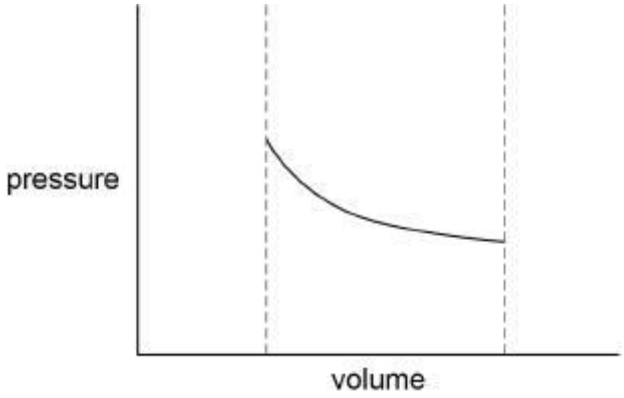
Determine V.

V = _____ m^3

(3)

Figure 2 shows how the pressure in the container and syringe varies with volume as the plunger is pushed in fully very slowly.

Figure 2



(c) Sketch on **Figure 2** the variation of pressure with volume when the plunger is pushed in fully very quickly and then left for several seconds.
Assume no leakage past the plunger.

(2)

(d) Explain why the compression of a gas can be considered to be an isothermal change when the gas is compressed very slowly.

_____

_____

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_____

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_____

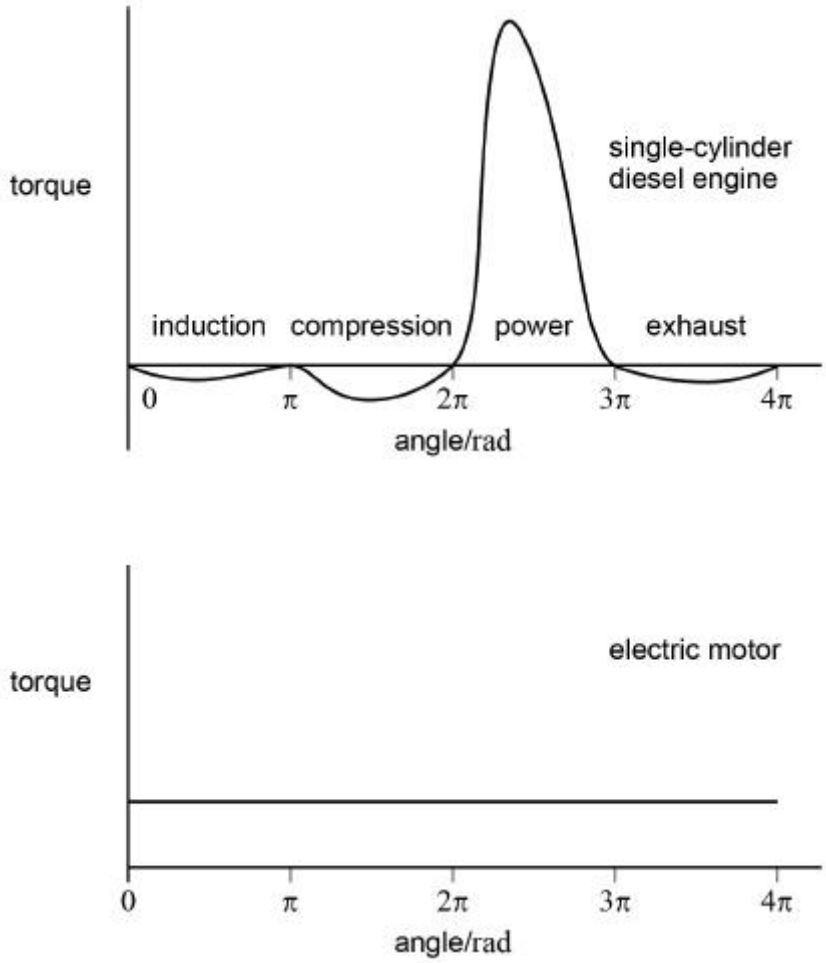
(2)

(Total 8 marks)

Q2.

A turning moment diagram is a graph showing the variation of torque produced by an engine or motor with the angle of rotation of the output shaft.

The graph below shows the turning moment diagrams for a single-cylinder diesel engine and an electric motor that have the same output power.



(a) State what is represented by the area between the curve and the angle axis for a turning moment diagram.

_____

_____

(1)

(b) The diesel engine or the electric motor may be used to drive a machine that has a low moment of inertia and that requires an almost constant torque.

Discuss why, to drive this machine, the diesel engine would need to be fitted with a flywheel.

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In your answer you should explain

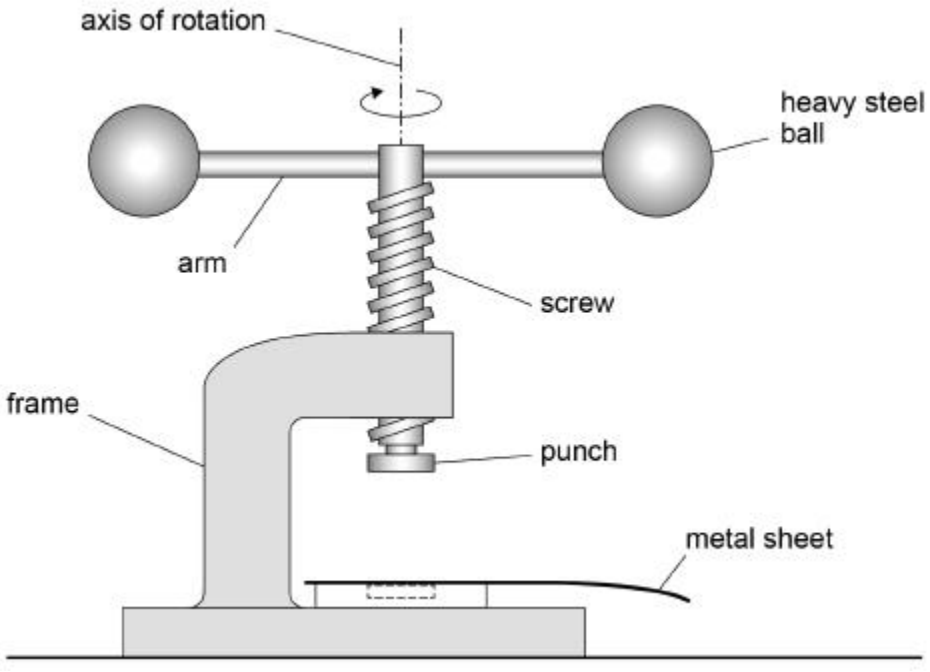
- why the electric motor does **not** require a flywheel
- why the torque of the diesel engine varies over one cycle, including why there are points where the torque is zero
- how the moment of inertia of the flywheel influences the motion of the output shaft of the diesel engine.

(6)

(Total 7 marks)

Q3.

The fly-press shown below is used by a jeweller to punch shapes out of a thin metal sheet.



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The frame holds a screw and punch. Two arms are attached to the screw, each loaded with a heavy steel ball. The screw is driven downwards when the arms are rotated.
Kinetic energy is stored in the rotating parts: the balls, arms, screw and punch. This energy is used to punch the shape out of the metal sheet.

(a) When the punch reaches the metal sheet, the rotational speed of the arms is 2.9 rev s^{-1}. At this speed the rotational kinetic energy of the rotating parts is 10.3 J.

Calculate the moment of inertia of the rotating parts about the axis of rotation.

moment of inertia = _____ kg m^2

(2)

(b) The total mass of the screw, punch and arms is the same as the total mass of the two balls.

Explain why the moment of inertia of the screw, punch and arms about the axis of rotation is **much** smaller than the moment of inertia of the steel balls about the same axis.

_____

_____

_____

_____

_____

_____

(2)

(c) During the punching of the metal sheet, the rotating parts of the fly-press are brought uniformly to rest from an initial rotational speed of 2.9 rev s^{-1} in a time of 89 ms.

Determine

- the angular deceleration
- the angle turned through by the rotating parts.

angular deceleration = _____ rad s^{-2}

angle = _____ rad

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(3)

(d) For thicker or stiffer metal sheets the rotational kinetic energy at 2.9 rev s^{-1} is not enough to punch out the shape.

The distance from the axis of rotation to the centre of each ball is y.

The radius of each ball is R.

The stored energy can be increased by

either

- increasing y by 15% without changing R

or

- increasing R by 15% without changing y.

Deduce which of these would produce the greater increase in stored energy.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(e) Which of the following is the SI unit for angular impulse?

Tick (✔) **one** box.

N m s^{-1} ☐

N s ☐

N m s ☐

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kg m^2 s^{-2} ☐

(1)

(Total 11 marks)

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