Name of the Student:_____
Max. Marks : 18 Marks **Time : 18 Minutes**

Q1.

(a) One equation used in translational dynamics is:

force = mass × acceleration

State **in words** the equivalent equation used in rotational dynamics.

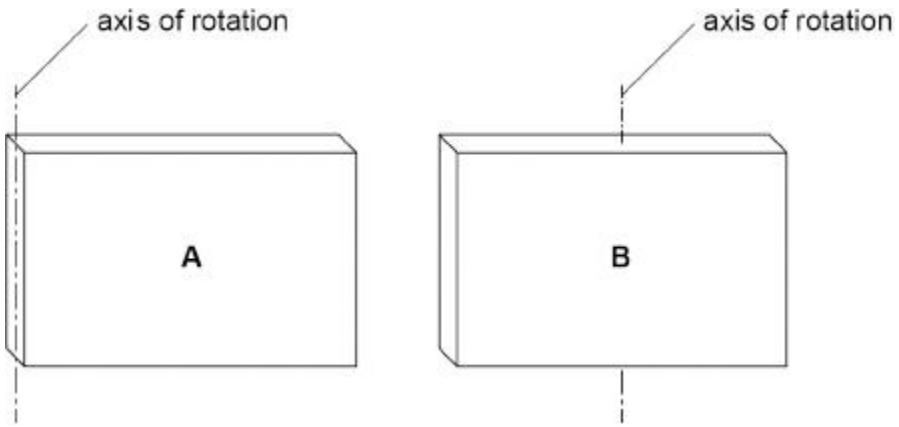
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(2)

Figure 1 shows two identical uniform plates **A** and **B**. The axis of rotation of each plate is shown.

Figure 1



(b) State and explain which plate has the greater moment of inertia about its axis of rotation.

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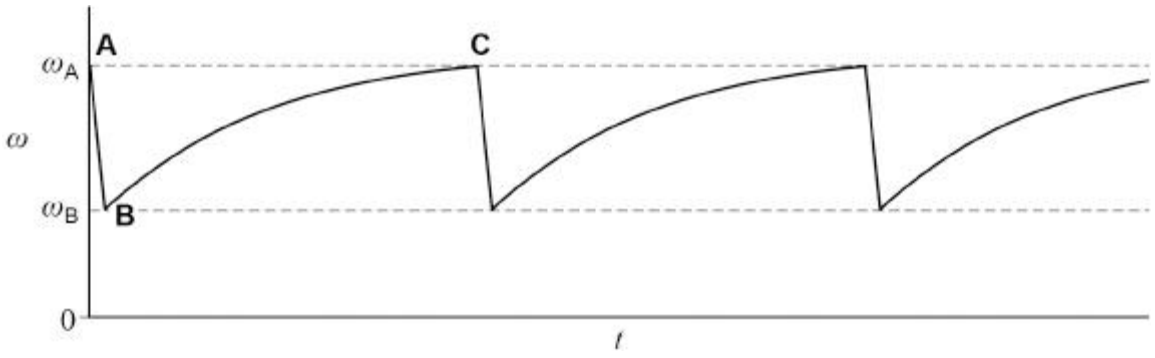
(2)

An electric motor drives a machine that punches out plates from a long strip of sheet metal. The motor runs continuously and is fitted with a flywheel. **Figure 2** shows how the angular velocity ω of

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the flywheel varies with time *t*.

Figure 2



The table below describes the sequence for the machine after it has been brought up to speed ω_A.

A	The punching operation starts.
A to **B**	The flywheel transfers some of its energy during the punching operation.
B to **C**	The flywheel is again brought up to speed ω_A by the motor.
C	The next punching operation starts.

(c) A new flywheel with a greater moment of inertia is fitted in place of the original flywheel. The motor torque is constant and the same as before.

Sketch on **Figure 2** a graph showing how the angular velocity varies with time for the machine fitted with the new flywheel.

Assume that:

- the punching operation starts at the same angular speed ω_A
- the same quantity of energy is transferred when punching the metal sheet.

(2)

(d) Explain **one** difference between your graph and the original graph.

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(1)

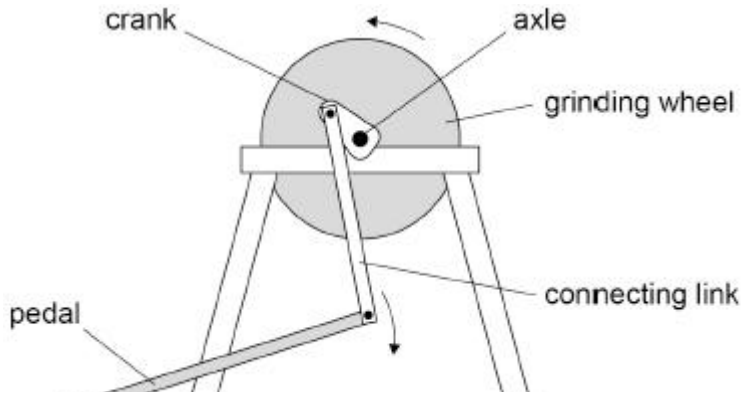
(Total 7 marks)

Q2.

Figure 1 shows a heavy stone grinding wheel used for sharpening tools.

Figure 1

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The pedal is connected to the axle of the wheel by a connecting link and crank.
The operator pushes the pedal downwards to accelerate the wheel from rest.
The wheel begins to rotate in the direction shown.

(a) Explain why the torque applied to the axle varies as the operator pushes downwards on the pedal.

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(2)

(b) The wheel is rotating at a high angular speed. The operator is told not to use the pedal to stop the rotation of the wheel suddenly.

Explain, with reference to angular impulse, why a sudden stop is likely to damage the mechanism.

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(2)

(c) The connecting link breaks. At this instant the angular speed of the wheel is 13.8 $\mathrm{rad\ s^{-1}}$.
It takes 15.0 s for the wheel to come to rest.
The frictional torque acting at the axle bearings is 0.77 $\mathrm{N\ m}$ and is constant for all speeds.

Calculate the moment of inertia of the wheel.

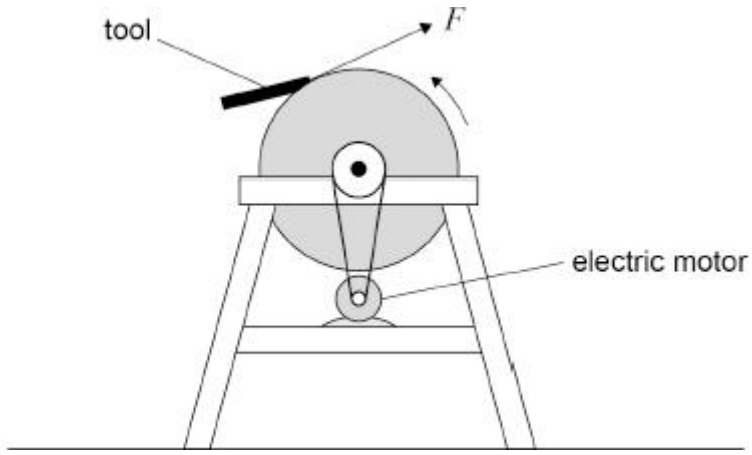
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moment of inertia = _____ $\mathrm{kg\ m^2}$

(2)

The arrangement is modified as shown in **Figure 2**. The pedal, connecting link and crank are removed and the grinding wheel is driven by an electric motor.

Figure 2



(d) **Figure 2** also shows a tool being sharpened by pressing it on the edge of the rotating wheel.
The tool applies a tangential force F on the wheel.
A torque of 3.10 $\mathrm{N\ m}$ is needed at the axle to drive the wheel at constant angular speed while the tool is being sharpened.

frictional torque at the axle bearings = 0.77 $\mathrm{N\ m}$
radius of wheel = 0.24 m

Calculate F.

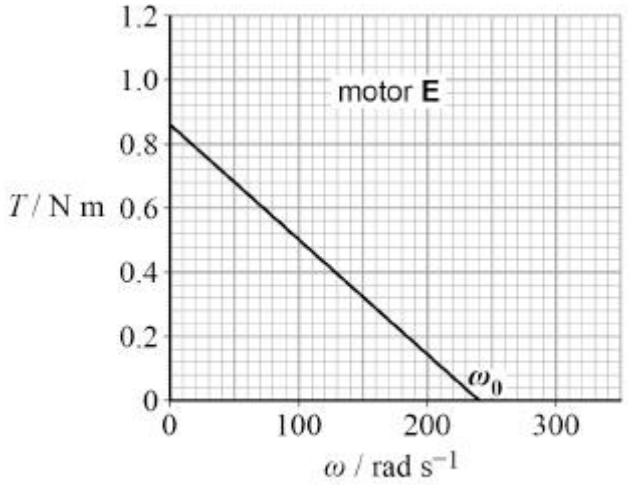
F = _____ N

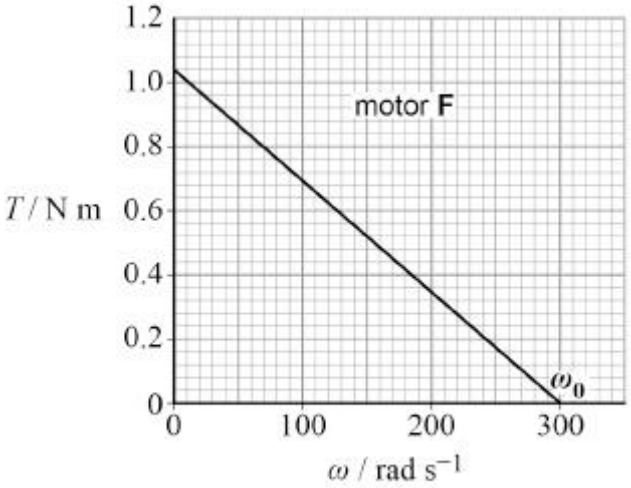
(2)

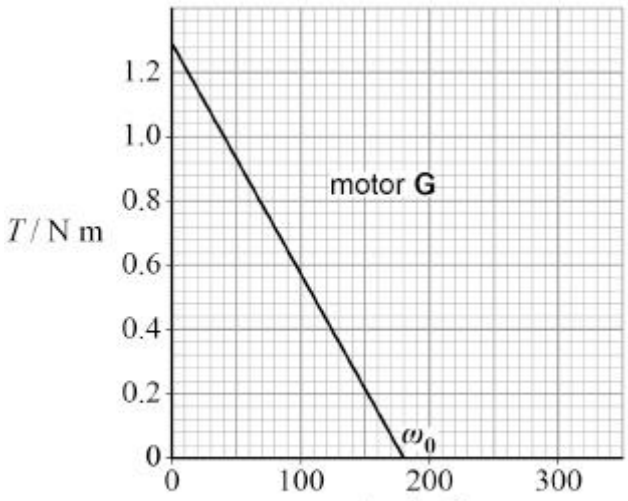
(e) Three motors **E**, **F** and **G** were available to drive the wheel in **Figure 2**.
Figure 3 shows how the torque T varies with angular speed ω for each motor.

Figure 3

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The no-load speed ω_0 is the angular speed of a motor when the torque applied is zero.
The maximum power of each motor is developed at about $0.5\omega_0$.
The required output power of the motor when a tool is being sharpened is 52 W.

The required output power of the chosen motor should be about $\frac{2}{3}$ of its maximum power.

Deduce which motor **E**, **F** or **G** was chosen for this application.

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(3)
(Total 11 marks)

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