

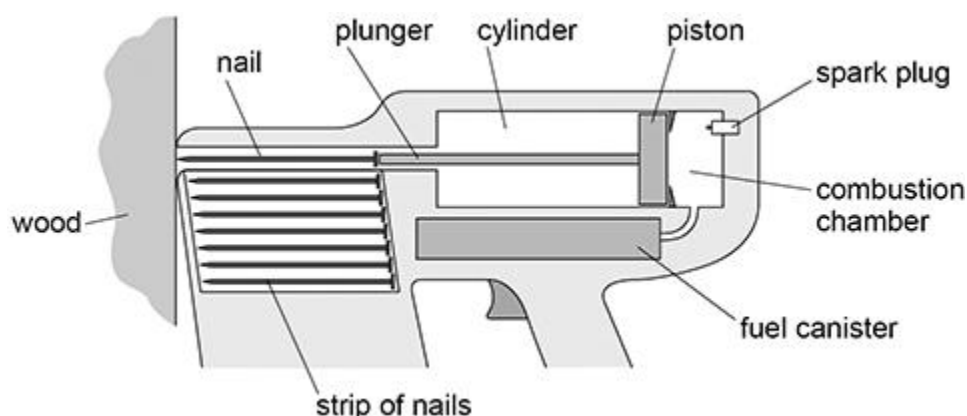
Name of the Student: _____

Max. Marks : 23 Marks

Time : 23 Minutes

Q1.

Figure 1 shows a tool for driving nails into wood. Only part of the tool is shown.

Figure 1

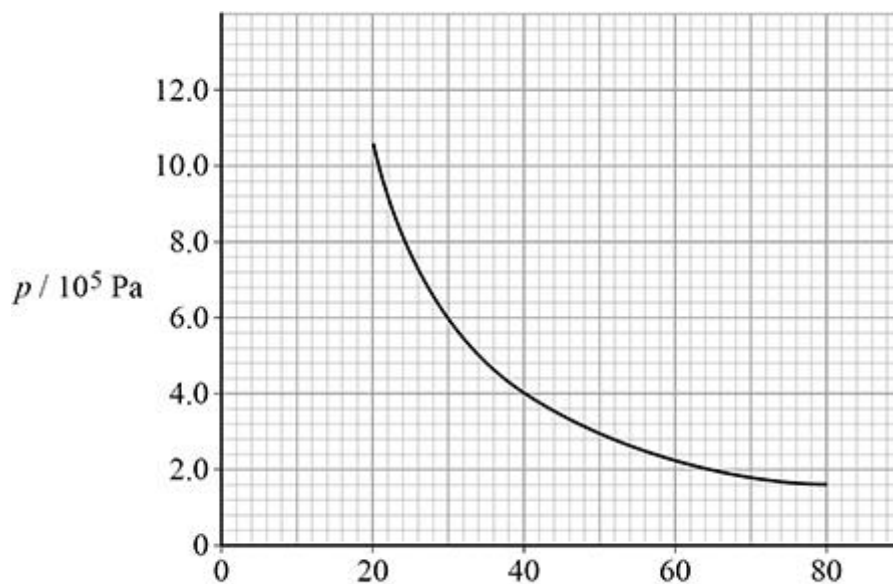
Fuel is mixed with air in the combustion chamber and is ignited by a spark. The gas expands rapidly and drives the piston along the cylinder. The plunger attached to the piston drives the nail into the wood.

The table below shows the average force needed to drive nails of various lengths completely into a particular type of wood.

Nail	Length / mm	Average force / N
A	32	250
B	38	320
C	45	370
D	50	420
E	63	560

- (a) **Figure 2** shows the variation of pressure p with volume V as the gas expands on the right-hand side of the piston when the correct nail is used.

Figure 2



The combustion chamber has a volume of $20 \times 10^{-6} \text{ m}^3$ and the piston moves through a volume of $60 \times 10^{-6} \text{ m}^3$.

The work done by the expanding gas is just enough to drive the correct nail completely into the wood.

Deduce which nail in the table above is the correct one to use in the tool.

(5)

- (b) After a nail has been used, another nail takes its place automatically. The tool can drive up to 180 nails per minute.

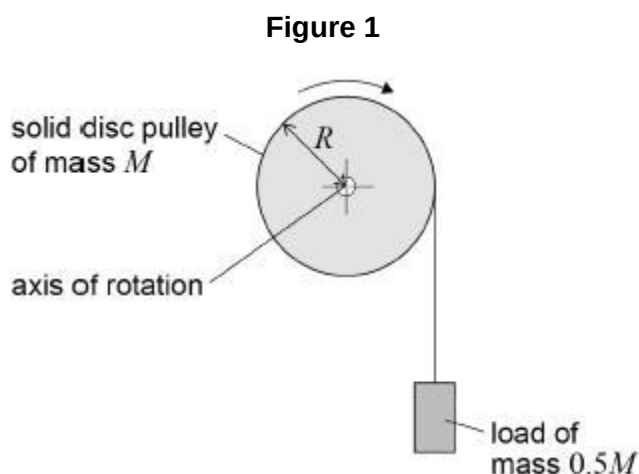
Discuss why the expansion **cannot** be isothermal.

Q2.

- (a) State what is meant by the moment of inertia of an object about an axis.

(1)

- (b) A student does an experiment using the apparatus shown in **Figure 1**.



A solid disc pulley of mass M and radius R is supported in bearings which have negligible friction.

A string of negligible mass is wrapped around the circumference of the pulley. A load of mass $0.5M$ is fixed to the free end of the string. The string does not slip on the pulley.

The moment of inertia of the pulley about the axis of rotation is $0.5MR^2$.

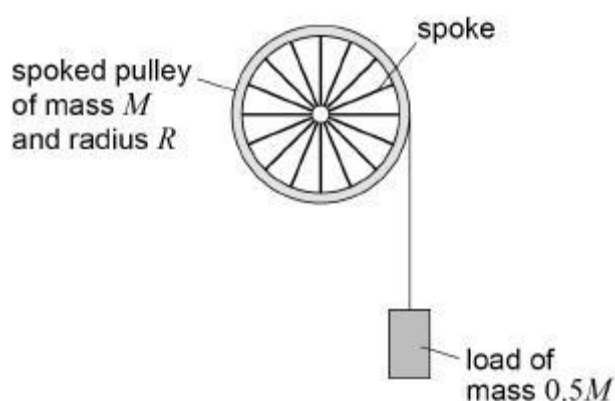
The student holds the pulley stationary.

When the student releases the pulley, the load accelerates downwards uniformly and is at a velocity v after moving a distance h .

Show that the acceleration of the load is $0.5g$.

- (c) The student repeats the experiment using a spoked pulley of the same mass and radius, as shown in **Figure 2**.

Figure 2



Compare the acceleration of the load in this experiment with its acceleration in the previous experiment.

A calculation is **not** required.

[illegible]

(3)

(Total 8 marks)

Q3.

- (a) State the condition necessary so that the law of conservation of angular momentum applies to a rotating system.

A clutch is used to connect two rotating shafts together so that they rotate at the same speed.

- (b) The figure shows two shafts, **A** and **B**, rotating freely about the same axis.
Table 1 gives information about the two shafts.

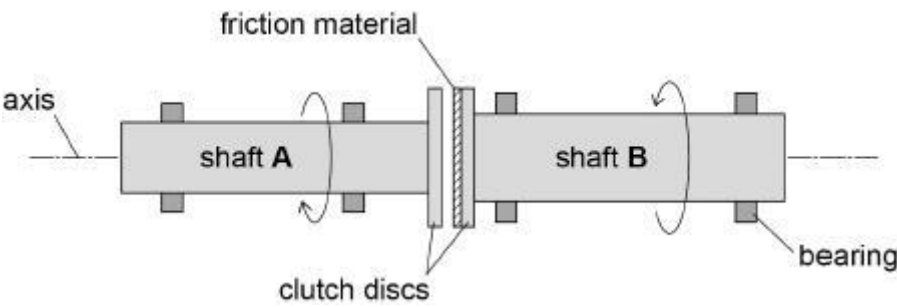


Table 1

	Shaft A	Shaft B
Angular speed / rad s ⁻¹	95	45
Moment of inertia / kg m ²	7.2	11.5
Direction of rotation	Clockwise looking from left	Anticlockwise looking from left

The two shafts are connected by forcing the clutch discs together.
Friction acts between the discs and slipping occurs for a short time until both shafts rotate at a common angular speed.
The clutch is now said to be engaged.

Show that the common angular speed of the two shafts immediately after the clutch is engaged is about 9 rad s⁻¹.

State whether the direction of the common angular speed is clockwise or anticlockwise when viewed from the left.

direction when viewed from the left = _____

- (c) **Table 2** gives information about two clutches, **C** and **D**.
C and **D** provide different constant frictional torques during slipping at the clutch discs.

Table 2

Clutch	Frictional torque during
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	slipping / N m
C	600
D	320

The slipping time is to be kept between 1.0 s and 2.0 s with the same initial conditions shown in **Table 1**, and the same final common angular speed.

Deduce whether either or both clutches allow this.

(3)
(Total 7 marks)