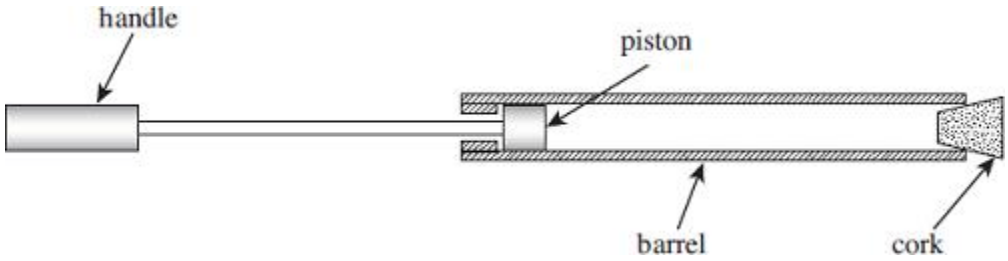
Name of the Student:_____
Max. Marks : 19 Marks **Time : 19 Minutes**

Q1.

The figure below shows a child's 'pop' gun in which a piston is pushed quickly along the barrel, compressing the air in the barrel. When the pressure is high enough, the cork is expelled at high speed from the end of the barrel.



The figure above shows the gun before it is 'fired'. The air in the barrel is at a pressure of 1.0×10^5 Pa, a temperature of 290 K and the volume is 2.1×10^{-5} m^3.

(a) (i) The volume of air in the barrel at the instant the cork is expelled is 1.2×10^{-5} m^3. Calculate the pressure of the air in the barrel at the instant the cork is expelled. Assume that the air is compressed adiabatically.
adiabatic index, γ, for air = 1.4

answer = _____ Pa
(2)

(ii) Calculate the maximum temperature reached by the air in the gun. Give your answer to an appropriate number of significant figures.

answer = _____ K
(3)

(b) The work needed to compress the air adiabatically from 2.1×10^{-5} m^3 to 1.2×10^{-5} m^3 is 1.4 J. Use the first law of thermodynamics to determine the change in internal energy of the air during the compression. Explain how you arrived at your answer.

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answer = _____ J

(2)

(c) Explain, giving your reasons, whether the volume of air in the barrel at the point when the cork leaves the gun would be less than, equal to, or greater than 1.2×10^{-5} m^3 if the handle of the gun had been pushed in slowly. Assume there is no leakage of air past the cork or piston. You may find it helpful to sketch a *p* - *V* diagram of the compression.

_____

_____

_____

_____

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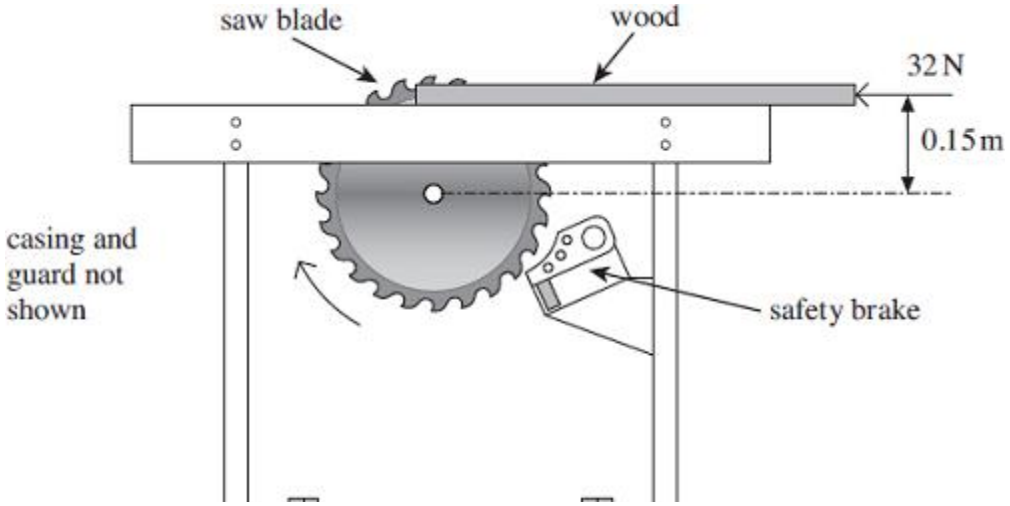
(3)

(Total 10 marks)

Q2.

The figure below shows a type of circular saw. The blade is driven by an electric motor and rotates at 2600 rev min^{-1} when cutting a piece of wood. A constant frictional torque of 1.2 Nm acts at the bearings of the motor and axle.

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A horizontal force of 32 N is needed to push a piece of wood into the saw. The force acts on the blade at an effective radius of 0.15 m.

(a) (i) Calculate the torque on the saw blade resulting from the horizontal force on the wood.

answer = _____ Nm

(1)

(ii) Calculate the output power of the motor when the saw is cutting the wood.

answer = _____ W

(3)

(b) Immediately after cutting the wood the motor is switched off. The time taken for the saw blade to come to rest is 8.5 s. Calculate the moment of inertia of the rotating parts (i.e. the motor rotor, axle and blade). State an appropriate unit.

answer = _____ unit = _____

(3)

(c) If the blade is accidentally touched when it is rotating, an electronic safety brake stops the blade in 5.0 ms. This is fast enough to prevent serious injury. The safety brake works by forcing a block of aluminium into the saw teeth.

Estimate the rate at which the rotational kinetic energy is dissipated as heat and in deforming the aluminium when the brake operates.

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answer = _____ W

(2)

(Total 9 marks)

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