Name of the Student:_____
Max. Marks : 17 Marks **Time : 17 Minutes**

Q1.

Figure 1 shows a robotic helicopter that is used on Mars. The helicopter is powered by a battery. Before each flight, the battery is charged by a solar panel.

Figure 1

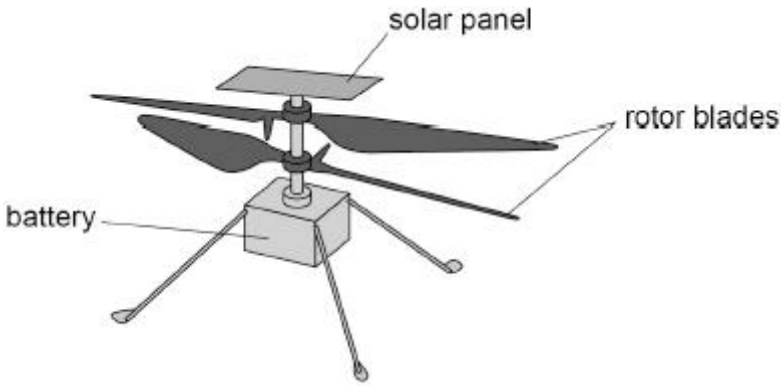
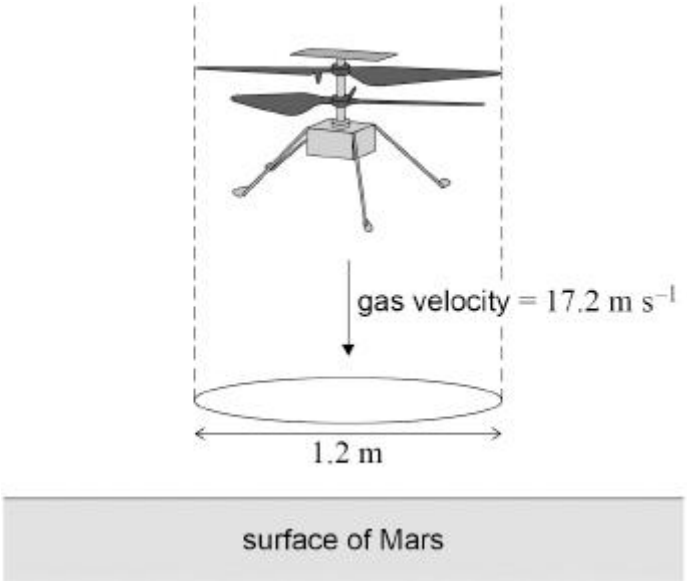


Figure 2 shows the helicopter hovering at a constant height above the surface of Mars. The rotor blades move a column of atmospheric gas vertically downwards at a velocity of 17.2 $\mathrm{m\ s^{-1}}$. The diameter of this column is 1.2 m.

Figure 2



(a) The gas moved by the rotor blades has a density of 0.020 $\mathrm{kg\ m^{-3}}$.

Show that the helicopter moves approximately 0.4 kg of gas every second.

(3)

The movement of the gas creates an upward force on the helicopter. This upward force enables the helicopter to hover at a constant height.

The gravitational field strength on Mars is 3.72 $\mathrm{N\ kg^{-1}}$.

(b) Calculate the mass of the helicopter.

mass = _____ kg

(3)

(c) The battery stores 0.035 $\mathrm{kW\ h}$ of energy before a flight.
The flight lasts for 39 s.
The battery has a power output of 340 W during the flight.

Determine the percentage of the initial energy stored in the battery that is transferred during the flight.

percentage = _____ %

(2)

(d) The helicopter has a maximum flight time of a few minutes due to the limited amount of energy stored in the battery. The battery accounts for about 15% of the helicopter's mass.

A student suggests that adding another identical battery that doubles the energy available to the helicopter would double its flight time.

Deduce without calculation whether the student's suggestion is correct.

_____

_____

_____

_____

_____

_____

_____

_____

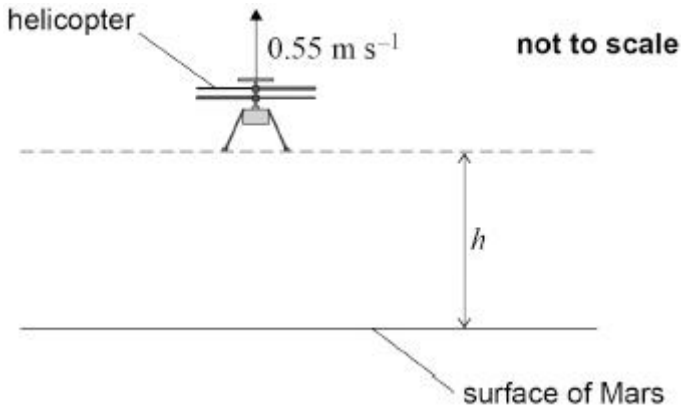
_____

_____

(3)

Figure 3 shows a simplified side view of the helicopter moving vertically upwards with a speed of 0.55 $\mathrm{m\ s^{-1}}$.
At the instant shown, the helicopter is at a height h and the blades stop rotating.

Figure 3



The gravitational field strength on Mars is 3.72 $\mathrm{N\ kg^{-1}}$.

The weight of the helicopter is the only force acting on it when the blades stop rotating. Drag forces on the helicopter are negligible as it rises to a maximum height and then falls back to the surface.

(e) Calculate the time taken for the helicopter to reach its maximum height from the instant the blades stop rotating.

time = _____ s

(2)

(f) When the helicopter makes contact with the surface it has a velocity of 2.2 $\mathrm{m\ s^{-1}}$.

Calculate h.

h = _____ m

(2)

(g) A student suggests that the acceleration of the helicopter is constant from the instant the blades stop rotating until the helicopter makes contact with the surface.

Discuss this suggestion with reference to an appropriate Newton's law of motion.

_____

_____

_____

_____

_____

(2)

(Total 17 marks)