7 Read the following article and answer the questions that follow.

Fig. 7.1

Pictured in Fig. 7.1 is the C-130 Hercules, manufactured by Lockheed Martin, and employed by Singapore Air Force. It has served numerous missions, such as operation Flying Eagle, which rendered assistance to Indonesia in the aftermath of the 2004 Tsunami.

The C-130 has the following data sheet.

Wing Surface Area	162 m^2
Operating mass	34 000 kg
Fuel energy density	45 MJ kg^{-1}

Fig. 7.2 shows the height and speed data, plotted with respect to time, during the flight of a C-130.

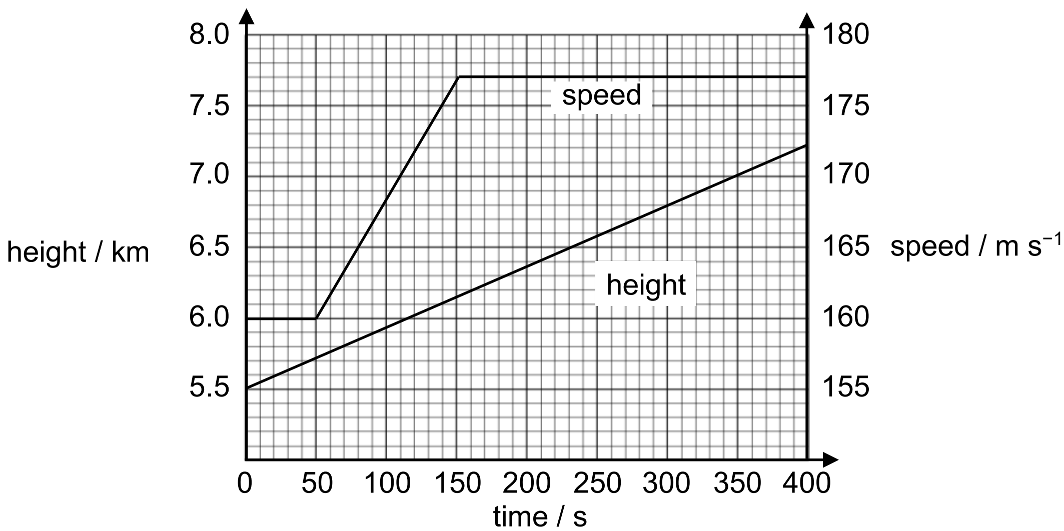

Fig. 7.2

(a) **(i)** With reference to Fig. 7.2, show that the vertical component of velocity of the aircraft is 4.3 m s^{-1}.

[1]

(ii) Hence, calculate the horizontal velocity of the aircraft at time $t = 200$ s, correct to 5 significant figures.

horizontal component of velocity = ……………………m s^{-1} [2]

(b) During the flight time of 400 s in Fig. 7.2,

(i) calculate the change in kinetic energy of the aircraft.

change in kinetic energy = ……………………J [2]

(ii) the aircraft's gravitational potential energy increases by 5.67×10^8 J.

Determine the highest value of useful power P_{useful}, given that P_{useful} is the sum of the power used for climbing and the power used to speed up.

highest value of P_{useful} = ……………………W [2]

(c) **(i)** Use the unit MJ kg^{-1} to deduce what is meant by fuel energy density.

………………………………………………………………………………………

……………………………………………………………………………… [1]

(ii) The efficiency of the aircraft is 24%. Calculate the mass of fuel required during the flight time of 400 s as shown in Fig. 7.2.

mass of fuel = ……………………kg [4]

(iii) State why the loss in fuel mass in **c(ii)** can be neglected in the calculation of the value in **b(i)**.

………………………………………………………………………………………………

……………………………………………………………………………………… [1]

(d) The following proposed relationship calculates the drag force, D, based on the values of the air density, ρ, aircraft speed, u, height, h, the wing surface area, S, and the coefficient of drag, C_D. S and C_D are constants.

$$D = \frac{1}{2} C_D S u^2 \rho$$

A table of data is provided in Fig. 7.3.

u / m s^{-1}	h / m	ρ / kg m^{-3}	$u^2\rho$ / kg m^{-1} s^{-2}	D / 10^6 N
160	5500	0.698	17900	1.160
167	5720	0.681	19000	1.231
177	5930	0.665	20800	1.348
177	6350	0.635	19900	1.290
177	6570	0.620		1.257

177	6800	0.603	18900	1.225

Fig. 7.3

(i) Complete the table for the value of $u^2 \rho$ when ρ is 0.620 kg m^{-3}. [1]

(ii) Fig. 7.4 is a graph of some of the data of Fig. 7.3.

Plot the point for when ρ is 0.620 kg m^{-3} on Fig. 7.4, and draw the line of best fit. [2]

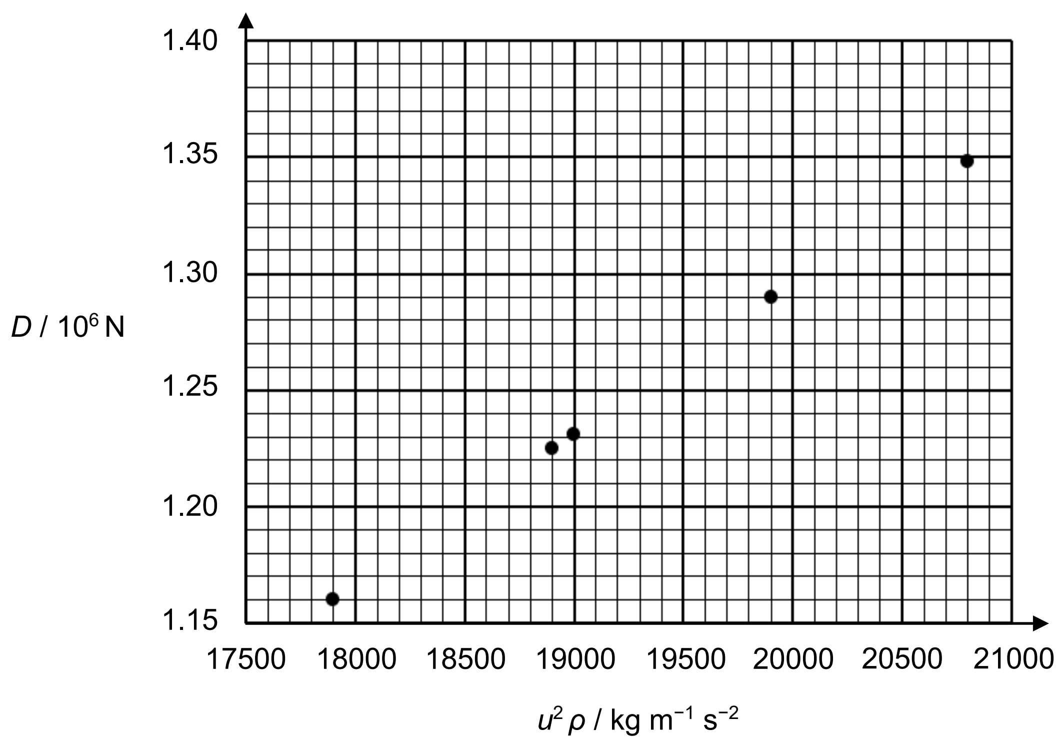

Fig. 7.4

(iii) Use Fig. 7.4 to determine the drag coefficient, C_D.

C_D = ……………………. [2]

(iv) Using the graph, or otherwise, show quantitatively that the graph of Fig. 7.4 supports the expression given in **(d)**.

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………….. [2]