PHYSICS SCHOLARSHIP 2013

CALCULATORS ARE NOT TO BE USED

Total marks available = 33

MOST OF THE MARKS IN THIS QUESTION ARE FOR SHOWING HOW WELL YOU CAN THINK. THE FINAL ANSWERS ARE LESS IMPORTANT THAN SHOWING THAT YOU CAN THINK AND WORK LOGICALLY.

You must show your working out at all stages and clearly state any assumptions that you are making.

Where you can, use powers of ten to show very big or very small numbers. For example 1,000,000 = 1.0×10^6

In October Felix Baumgartner jumped out of a balloon 24 miles above the Earth. This question is about some of the Physics involved in his jump.



1. Felix jumped out at a height of 24 miles.

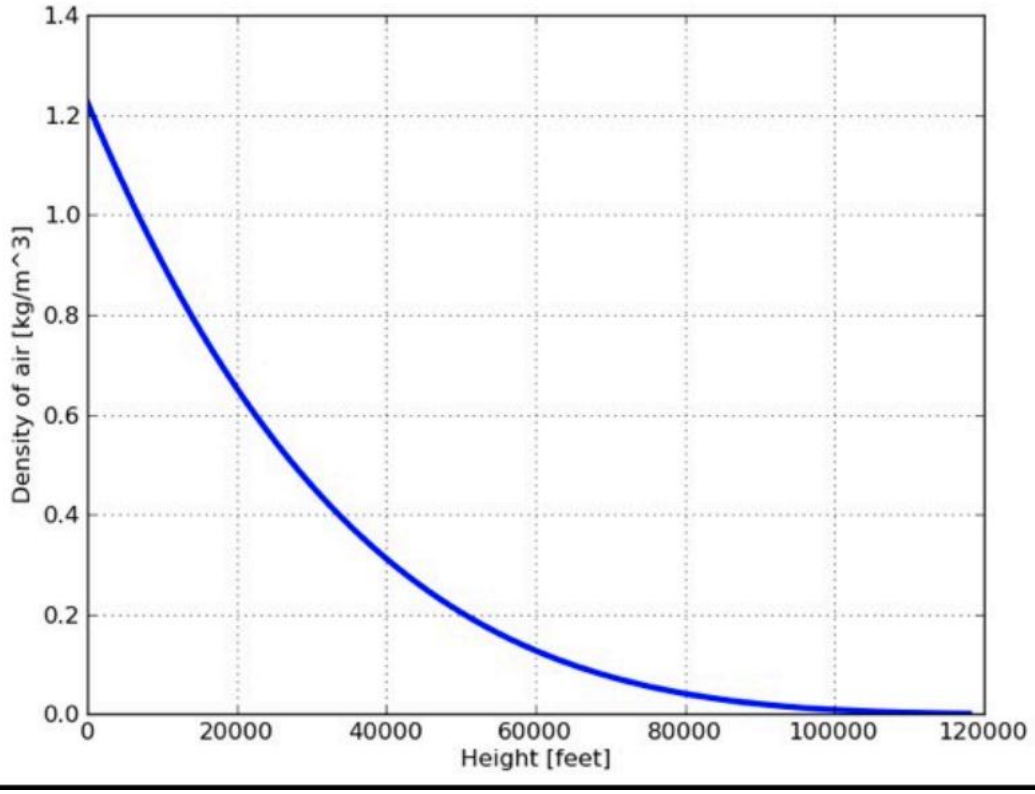
   a. Convert this into metres. [2 marks]

   1 mile = 1600 metres

   b. Now convert it into feet. [2 marks]

   1 mile = 5300 feet

You might have read that Felix jumped out "from the edge of space". What we mean by this is that the density of air was at or very close to zero. The graph below shows the density of air (in Kg/m^3) varies with height above the ground. Use it to answer the questions below.



2. What is the density of air at ground level? [1 mark]

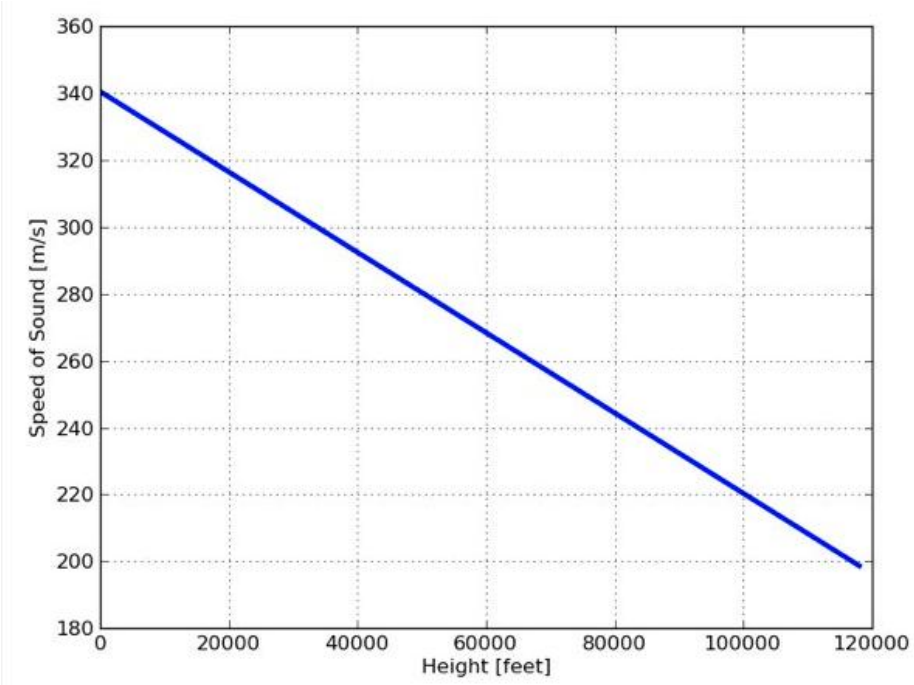
3. Estimate the volume of the room you are sitting in doing this exam. Show clearly how you arrived at your answer. [3 marks]

4. Using your answers to the previous two questions, calculate the the mass of air in the room in which you are sitting. [4 marks]

5. What height would you have to be at for the mass of air in the room to be reduced by 75%? [2 marks]

6. Use the graph to comment on whether you think Felix did jump from the edge of space. [2 marks]

You might also have read that Felix travelled faster than the speed of sound during his fall back to Earth. To understand this, we need to use the fact that the speed of sound varies depending upon your height above the ground. The graph below shows how it varies.



Key freefall timings/altitudes/speeds:
At 34 seconds into freefall, Felix goes supersonic.
Altitude: 33,446 m / 109,731 ft
Speed: 1115 kmh / 693 mph

7. The mission data about Felix's fall is above. Use it and the graph above to answer the questions below.

a. Use the graph to find the speed of sound in metres per second (m/s) at the height where Felix went supersonic 34 seconds into his fall? [2 marks]

b. Convert this speed from metres per second (m/s) into kilometres per hour (kmh). [4 marks]

c. How much faster than the speed of sound was Felix travelling 34 seconds into his flight? [2 marks]

For the next few minutes of Felix's fall, the data is shown below.

At 50 seconds into freefall, Felix reaches maximum vertical speed.
Altitude: 27,833 m / 91,315.6 ft
Speed: 1,357.6 kmh / 843.6 mph

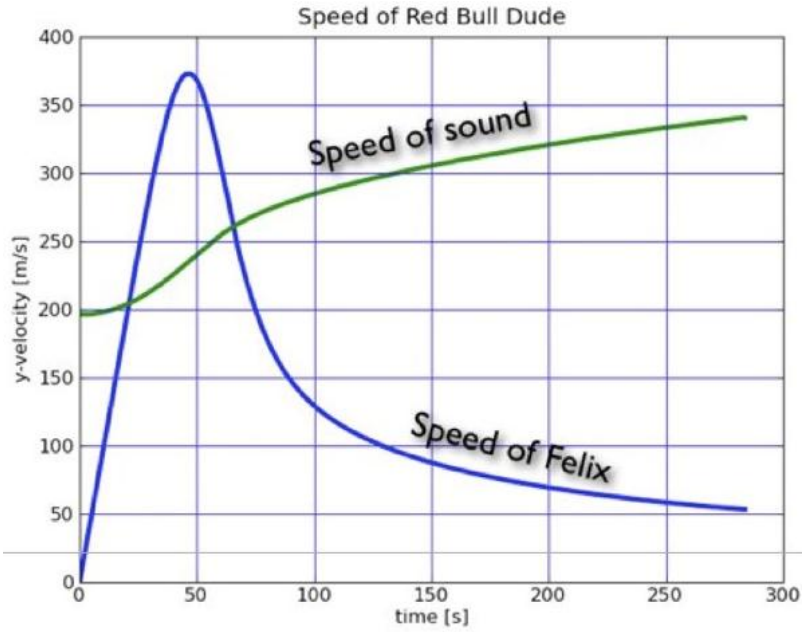
At 64 seconds into freefall Felix becomes subsonic.
Altitude: 22,960.7 m / 75,330.4 ft
Speed: 1,043 kmh / 648 mph

At 180 seconds into freefall, speed has slowed substantially.
Altitude: 7,619.3 m / 24,997.7 ft
Speed: 285 kmh / 177 mph

8. Explain why Felix's speed changes as shown by the information above. [3 marks]

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Look at the graph below



9. For approximately how long was Felix was travelling faster than the speed of sound? [1 mark]

10. Show on the graph where Felix was travelling at **exactly** the speed of sound? [1 mark]

During Felix's fall, the caption below appeared on a news programme in the USA.



11. Use your answer to question 1a to calculate how long Felix would have taken to fall to earth if he had fallen at the speed of light from the moment he stepped out of the balloon. [4 marks]

The speed of light is 3×10^8 m/s.

The graphs in this question are from : http://www.wired.com/wiredscience/2012/02/stratos-space-jump-can-you-fall-faster-than-the-speed-of-sound/