Space awaits you – by courtesy of Sir Richard Branson

On an epic journey, 11 July 2021, Sir Richard and fellow crew members became the first people to take a commercial flight into space. It had been his dream to make this trip since witnessing the launch of Sputnik 1 from the R-7 rocket on 4th Oct. 1957 and he has worked tirelessly over the past 17 years to develop an imaginative route to journey to the edge of space.

A specially designed aircraft named Virgin MotherShip (VMS), or Eve for short, took the Virgin SpaceShip, Unity 22 (VSS 22) to a height of about 18 km (~50,000 feet) as shown in Fig 1

Fig 1 Mother aircraft with the Virgin SpaceShip attached prior to launch

Moments later Unity 22 was released and then used rocket power to propel four passengers, plus two pilots Dave Mackay and Michael Masucci to a height of almost 100 km above the surface of the earth.

Data has been extracted from the data stream that was displayed at the edge of the picture (Fig 1) and the height of Unity 22 is recorded in Fig 2;

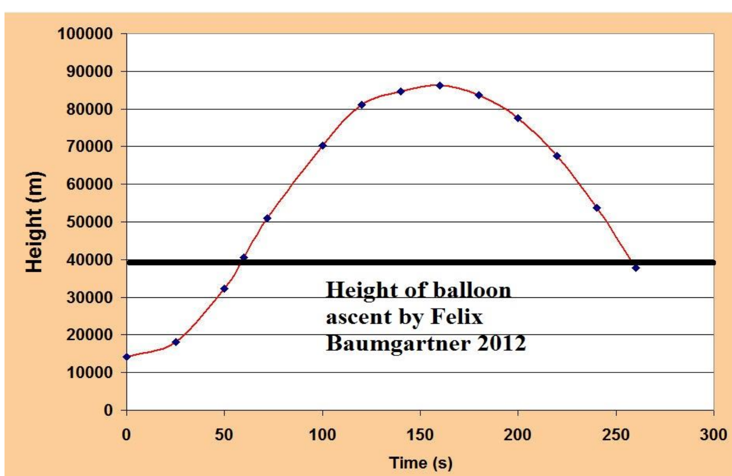

Fig 2 Height data for the Parabolic Trajectory of Unity 22

It is observed that the height of Unity 22 was above the 80 km limit that is generally recognised as the edge of space [1] and more than twice the height that the sky-diver Felix Baumgartner had achieved in a balloon ascent several years earlier [2] (he, too, was part of the Stratos program that was a commercial venture).
In the time period 72 s to 240 s the space plane is subject ***only*** to the pull from earth with a very small frictional force and therefore should follow a parabolic path according to the laws of motion, namely

$$y = -1/2gt^2 + ut + c$$

where c is a constant, u is an initial speed and g is the acceleration due to gravity

Fitting a polynomial of order 2 to these points gives the equation:

$$y = -4.83t^2 + 1520t - 33128$$

$$R^2 = .998$$

The correlation factor, R^2 ,indicates that VSS 22 did follow a parabolic curve very closely and the g-value, at 9.66, is only about 2% lower than the value at sea-level. This is to be expected as a computation from the gravitational square law gives a similar reduction.

The speed of Unity 22 after launch is given in Fig 3:

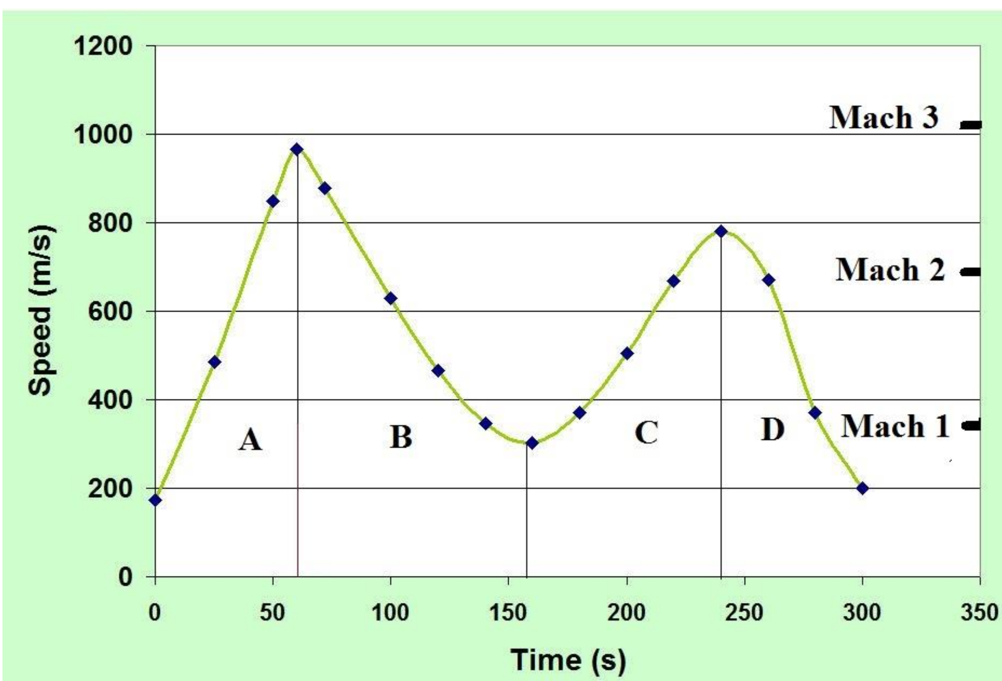

Fig 3 Graph showing speed versus time for Unity 22

Four regions are identified:
A – for the first 60 seconds the upwards speed is increased dramatically when the rocket boost is applied. A speed of almost Mach 3 is achieved.
B – there is then a decrease in the speed of ascent as gravity slows Unity 22 to almost below Mach 1. This is the highest point on the parabolic trajectory as shown on Fig 2. The term used for the highest point is “Apogee”.
C – now Unity 22 is beginning it’s descent and, as the atmosphere is very rarefied at these heights, there is a minimal drag force. Therefore the gravitational pull of earth accelerates the craft to speeds approaching Mach 2.5.
D – the rate of descent now slows considerably as the atmosphere becomes ever more dense and results in a significant drag force to oppose the gravitational pull towards earth. Unity 22 has a novel fin system to slow the craft down (acting rather like as a shuttle cock it is called a feathering system) and this would likely have been deployed at this time.
A video sequence can be seen via the following link:
https://www.youtube.com/watch?v=pl0ad1O-2BU

It may be noted that Baumgartner descent speed increased to over Mach 1 before slowing down to the usual terminal velocity. Fuller details about the density of the atmosphere are given in reference [2] to explain any feature of the Unity 22 flight.
The sensation of weightlessness is prevalent in any parabolic flight [3] and passengers in Unity 22 flight experienced this at times between about 100 and 200 seconds after the initiation of the rocket boost. Pictures of them floating in the cabin are rather indistinct.

The flight after 300 seconds (5 minutes) was very much like that in a normal passenger aircraft and the subsequent landing on a runway went without incident. I feel one has to salute Sir Richard for his vision, tenacity and courage in completing a mission with unqualified success. Many dangers are present when flying to space but this flawless expedition would suggest that the technical challenges have been overcome and that “space” is now open to the commercial world. It must rate highly as a cost-effective method of travelling to the edge of space as VMS and VSS are reusable and only the rocket fuel has to be replenished.
At a classroom level any voyage into space excites the imagination of students/pupils and, together with the Stratos project [2], it is an area rich in Physics. It may well be that future flights will address topics in Atmospheric Physics and, who knows, may shed some light on our Climate Change challenges.
References
[1] J. C. Mc Dowell (2018), “The Edge of Space – Revisiting the Karman Line”, Acta Astronautica, **151**, p668 .
[2] F R Greening (2013), “Baumgartner’s jump and the physics of free fall”, Phys. Ed. **48** p139 .
[3] F. Karmali and M. Shelhamer (2008), “The Dynamics of parabolic flight: Flight characteristics and passenger percepts”, Acta Astronautica, **63** p594.
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