

Microgravity

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Abstract: This project in its present form is the result of the question "Why Astronauts go to Space?" the initial idea was to find out the reason behind the same. After doing some research works finally the conclusion was that the astronauts get microgravity region in space, so that many experimental works may be done there which are not possible on earth due to gravity. Then it was found out what exactly Microgravity is? How and why is it so beneficial that space shuttles are being launched? Then some newly found methods of achieving Microgravity inside the earth's atmosphere have also been researched on. The results were Drop towers, Sounding rockets, Space shuttle and finally Airplane flying in a parabola. This project has some new areas of research included which would lead one to think beyond normal. Such as a unique way of achieving Microgravity on earth.

Keywords: Microgravity, Parabola, Astronauts, Free fall.

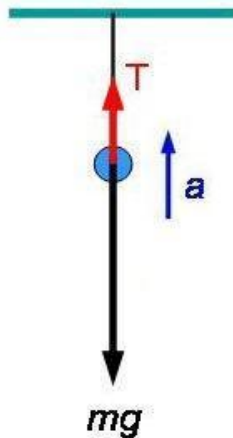
Nomenclature:

m	Mass
T_r	Thrust
g	Gravitational force
a	Acceleration
ψ	Yaw angle
T	Tension
L	Lift
D	Drag
$0g$	Microgravity

Introduction:

Out of the many valid reasons for, "why astronauts go to space?" is that space flight allows scientists to investigate the fundamental states of matter – solids, liquids & gaseous. And most importantly the forces that affect them in a microgravity environment. For obvious reasons, these studies in a microgravity region are an exciting opportunity to expand the frontiers of science. One of the most promising new areas for the commercialization of space is in the field of microgravity. A microgravity is one in which the apparent weight of a system or object is small as compared to its actual weight due to gravity. OR more precisely, to say, Microgravity also called weightlessness or zero gravity is the absence of gravity. The term microgravity can be interpreted in a number of ways depending upon context. A microgravity environment is one that will impart to an object a net acceleration small compared with that produced by Earth at its surface. In practice, such accelerations will range from about one percent of Earth's gravitational acceleration (aboard aircraft in parabolic flight) to better than one part in a million (for example, aboard Earth-orbiting free flyers). Another common usage of micro- is found in quantitative systems of measurement, such as the metric system, where micro- means one part in a million. By this definition, the acceleration imparted to an object in microgravity will be one-millionth (10^{-6}) of that measured at Earth's surface. The use of the term microgravity corresponds to small gravity levels or low gravity. The fidelity of the microgravity environment depends on the mechanism used to create it. For instance if one steps off a roof that is five meters high, it would take him just one second to reach the ground. In a microgravity environment equal to one percent of Earth's gravitational

pull, the same drop would take 10 seconds. In a microgravity environment equal to one-millionth of Earth's gravitational pull, the same drop would take 1,000 seconds or about 17 minutes! Microgravity can be created in two ways. Because gravitational pull diminishes with distance, one way to create a microgravity environment is to travel away from Earth. To reach a point where Earth's gravitational pull is reduced to one-millionth of that at the surface, one would have to travel into space a distance of 6.37 million kilometres from Earth. This approach is impractical, except for automated spacecraft, since humans have yet to travel farther away from Earth than the distance to the Moon. However, a more practical microgravity environment can be created through the act of free fall. Imagine riding in an elevator to the top floor of a very tall building. At the top, the cables supporting the car break, causing the car and you to fall to the ground. (Discounting the effects of air friction on the falling car.) Since the person and the elevator car are falling together, one will float inside the car. In other words, the person and the elevator car are accelerating downward at the same rate & thus the state of free fall occurs, creating microgravity. The possibility of using the earth's gravity to reduce the effect of gravity within a system was not always evident. Albert Einstein once said, "I was sitting in the patent office at Bern when all of a sudden a thought occurred to me, if a person falls freely, he will not feel his own weight." Working with this knowledge, scientists concluded that microgravity experiments could be performed by crew members while in orbit. This led to the invention of airplane flying in a parabola for creation of microgravity inside the earth's atmosphere. This is by far, one of the most beneficial inventions for mankind & by the mankind.

Mathematical formulations:

eradicate more than half of the poverty of India alone. So it became the need of an hour to find something which could overcome all the above listed drawbacks. Then came into picture “the airplane flying in a parabola”.

Now considering an example of the elevator car, the mathematical expression for zero gravity can be derived as follows: The elevator car is being lifted up by the force ‘T’ Newton i.e. tension in the cable with an acceleration of say ‘a’ meters per second squared. Now this tension is acting in the upward direction whereas, gravity will act on the same in the downward direction. We know that $F=ma$, by Newton’s law of motion. So this upward tension in the cable is also a force hence we equate these two. We get, $T - mg = ma$... (1) Now we cut the cable from the elevator so that the tension T becomes zero. Substituting this in equation (1), We get, $0 - mg = ma$ Taking ‘m’ common & rearranging the terms $m(g+a) = 0$ We know that mass can never be zero. Therefore $g+a = 0$... (2) Now our upward acceleration tends to be zero & this is the time when gravity comes into picture. As soon as the cable is cut the gravity component dominates the upward acceleration & for this time period acceleration is changing its Polaroid. During this process acceleration has to be zero for some time. So substituting the value of ‘a’ as zero in equation (2) We get, $g+0 = 0$ Thereby making $g=0$. Which is nothing but our very concerned zero gravity or microgravity. Hence we can say that “if acceleration tends to zero then our gravity also tends to zero”.

Experimental methods:

As has already been stated that microgravity can be created in two ways. The former one being impracticable, scientists found out some different & practicable methods for creating microgravity. The first one being called as drop tower is nothing but a simple tower in which the payload is simply dropped off the top of the tower. This payload gets into the state of freefall thereby giving us 2-7 seconds of microgravity. Since this is too short to carry out any experiment therefore the concept of sounding rocket came into being. This is a rocket which goes up & comes down in the same general vicinity never getting into orbit. This provides us with 3-9 minutes of 0g but this method is too expensive for regular usage. There is another device which gives us days of 0g which is space shuttle. As space itself is a reduced gravity region therefore as many days we spend in space we get 0g environment. But this is so expensive that if the launching of one space shuttle is skipped then the same amount of purchasing power can

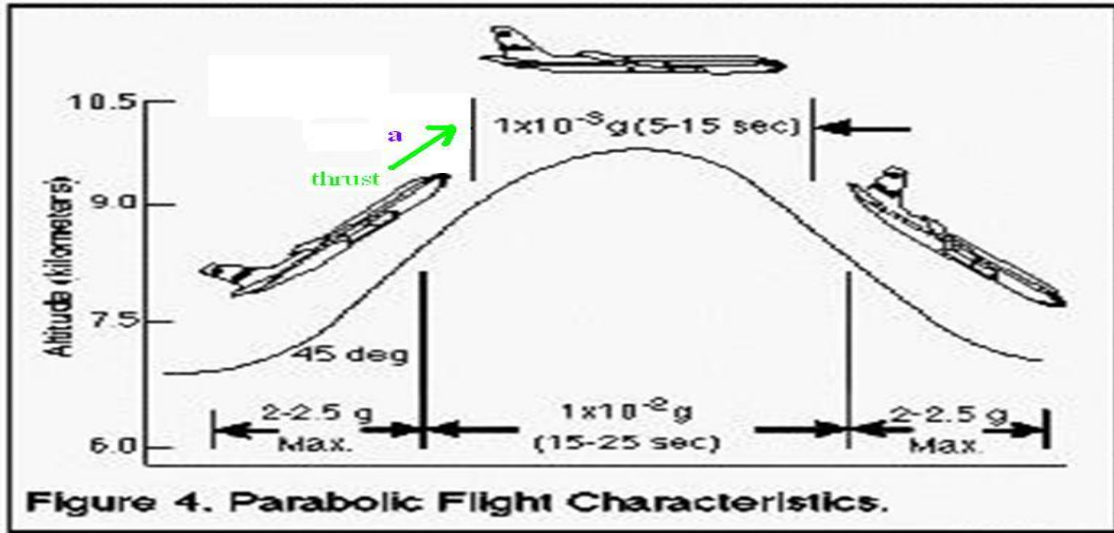
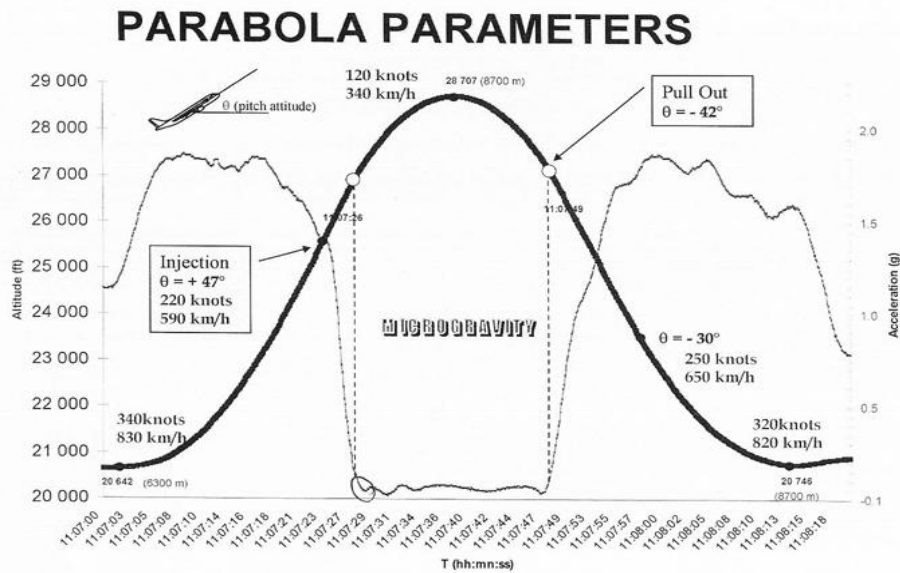


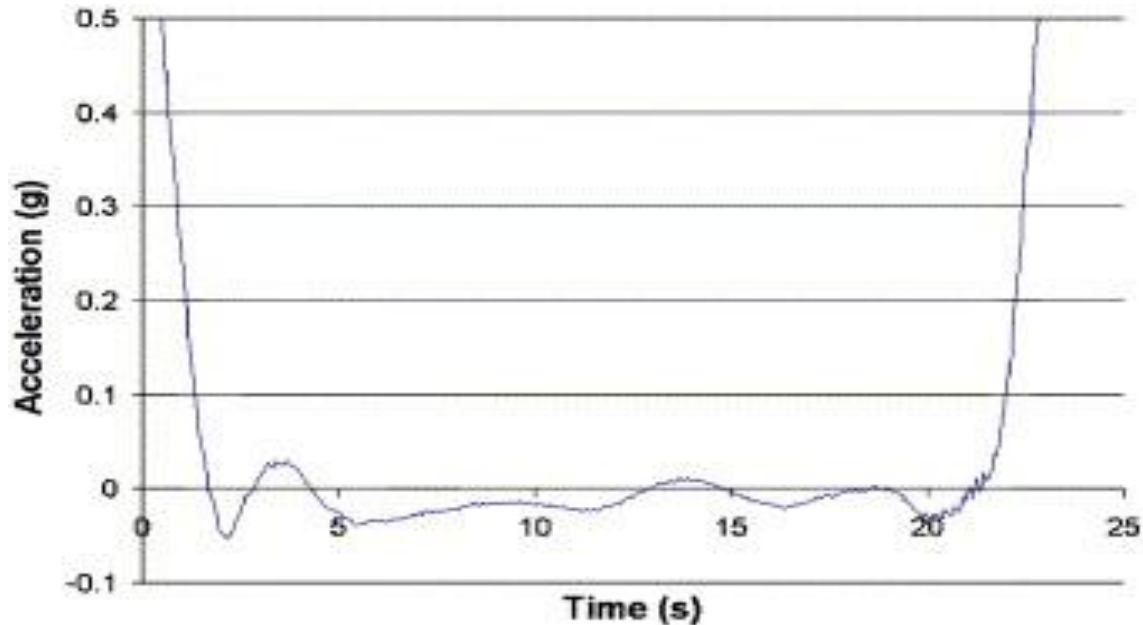
Figure 4. Parabolic Flight Characteristics.



Airplanes are used to achieve reduced gravity conditions for periods of about 20-25 seconds. This environment is created as the plane flies in a parabolic path. These planes, also known as 'vomit comets', firstly are flown around 9-10 kms above sea level. So at this altitude the gravity we encounter is 2-2.5 g. Then the airplane is made to form a pitch angle of 45 degree & is lifted at this angle with its elevators kept down. Just as the airplane gets a bit lifted, the engines are turned off. This makes the thrust tend to zero & so does our acceleration tends to the same. At this condition when there is no acceleration of its own, the airplane tends to fall & traces a parabolic path as it tends to fall. As soon as this condition is achieved the engines are turned on, thereby propelling it once again. So then when are we encountering 0g? It's the period from when the

engine is turned off to the moment the engine is switched on. Because at this state everything inside the airplane encounters free fall condition & then 20-25 seconds of microgravity are achieved. The same procedure is repeated for 2-3 hours in continuation so that the crew members get 40 periods of microgravity. This method is economical, practically achievable, and useful for regular purpose.

Result & conclusion:



Now finally coming to our conclusion it must be mentioned that microgravity is one of the fastest growing areas of research in today's world because new materials can be found out for the myriad applications like improving fiber optics, speeding up future computers, etc. The diseases like cancer & AIDS are likely to be cured by the medicines made in microgravity region. The main reason behind these many experiments done in 0g is that these experiments allow us to open new areas for research as everything on earth has to be under the effect of gravity. Whereas, 0g region allows one to think beyond the bars & to achieve incredible heights in near future. Taking into consideration the present status of microgravity, we can say that the time is not far when this stream would be one of the dominating stream in the field of research & development.

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