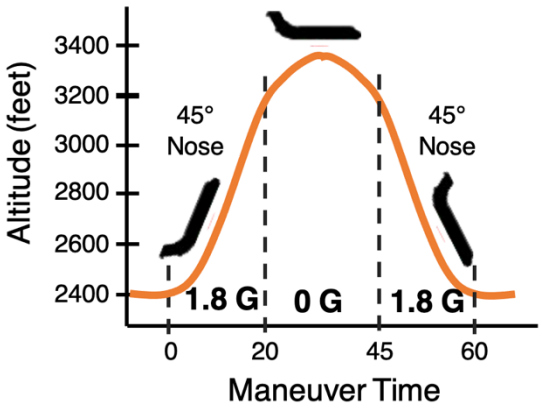
Weightlessness Training

Since 1957, the National Aeronautics and Space Administration (NASA) has used fixed wing aircraft to train astronauts for the effects of weightless sensations. The airplanes consist of an empty cabin with padded floors. The flight path of the plane is a collection of consecutive parabolas. Each parabola begins with a 45-degree climb. Twenty seconds into the climb, the thrust of the plane is reduced and the pilot makes an effort to gradually and steadily turn the nose of the plane downward. It is during this time that passengers experience a *zero-G* environment. This weightless experience lasts for nearly 25 seconds as the plane does its notorious *up and over the hump* maneuver. The plane then pulls out of its nose dive, inducing sensations of heaviness in its passengers. Each parabola lasts for approximately 65 seconds. **Figure 1** shows the plane's path and the various sensations that are experienced.

Figure 1



The sensation of weightlessness is due to the absence of support forces. Normally, an 80-kg astronaut would experience about 800 Newton of upward force. This upward force balances the downward force of gravity. It is the presence of the upward force that gives an astronaut a sensation of weight. When in a *zero-G* environment as shown in **Figure 2**, this upward force is absent and the astronaut has no sensation of having weight; they *feel weightless*. Sensations of heaviness are experienced when the support force is greater than the downward force of gravity. This sensation occurs when a downward moving astronaut is slowing down. If the support force is three times greater than the force of gravity, then the astronaut is said to be experiencing *three G's of force*. The diagrams in **Figure 3** are free-body diagrams. The arrows represent the two forces acting upon an astronaut under normal conditions (**A**), partially weightless conditions (**B**), perfectly weightless conditions (**C**), and heavier-than-normal conditions (**D**).

Figure 2

Figure 3: Sensations of Weight