Austrian skydiver felix baumgartner philosophy essay

Philosophy

At the moment Felix jumped from the Red Bull capsule, he was at height above the surface of the Earth of 39, 045 meters. At this point, the vertical motion of the helium balloon was so slight therefore will be assumed to be effectively zero. In order to know how fast Felix accelerates when leaping from the balloon capsule, his acceleration due to gravity then need to be calculated and this requires lot of efforts where the drag force, air density, pressure, terminal velocity, and speed of sound are all must be taken into account. By doing so, we could prove or see on how Felix's velocity during the first 40 seconds freefall has reached supersonic, that is Mach 1. 24. Firstly, the strength of a gravitational field is inversely proportional to the to the square of the distance, r from the centre of the Earth which in this case is Felix's distance from the centre of the Earth. This consequently means the gravity gradually weakens the further away Felix risen up to a height above the Earth. This in turn means the force of gravity Felix experienced will be very slightly smaller than the standard gravity of 9. 81 m/s2. The acceleration due to gravity is calculated by using equation as follow: a = GM/r2 eq. (1)where G is the gravitational constant = 6. 67384 x 10-11N (m/kg2), and mass of the Earth, M = 5. 97219 x 1024 kg and r is the radius from the centre of the Earth to Felix's capsule. The distance, r then has to be worked out in order to determine the value of gravitational acceleration, a.

a) Calculate the distance from the centre of the Earth

We know that Felix leapt from an altitude of 39045 meters, therefore by adding that to the radius of the Earth will give to the Felix's distance from the earth. However, the radius of the Earth depends on Felix's latitude and it would vary between 6350 km and 6390 km because of the Earth that deforms into an oblate spheroid. By gathering some information, Felix launched the skydive more or less over Roswell in New Mexico, which is at latitude 33. 3942°North. To work out the radius of the Earth at this latitude, the polar radius and equitorial radius need to have values first. The equation of the radius of the earth is shown as follow; R(ϕ) = eq. (2)Where, R is the radius at latitude ϕ, a is the equitorial radius, and b refers to the polar radius. A quick search from the web gives a and b values of 6384. 4 km and 6352. 8km respectively. Then, substitute these two values into equation (2);ϕ= 33. 3942 Degree; a= 6384. 4;

b= 6352. 8;

Now, value of R computed is 6374. 91 km which is expressed in meter gives 6374910 m. Therefore, we need to add the 39, 045 meters of Felix's altitude to this radius in order to get a proper value of r (total value of Felix's distance) to be substituted in our gravitational acceleration equation (1). Therefore, Felix's distance from the centre of the Earth when he leapt was 6, 413, 955 meters. Now substitute all the values defined into equation (1) so as to calculate Felix's acceleration due to gravity; From the computation above, Felix's initial acceleration is 9. 689 m/s2 as opposed to 9. 81 m/s2 gravitational acceleration near the surface of the Earth.

Determine the temperature at Felix's altitude

First and foremost, the relationship of temperature changes at different altitude should be learned. This can be simply done by sending query to WolframAlpha. By referring to Figure 1, it can be seen clearly that the temperature does not change linearly with altitude, instead it rises and falls dependently on factors such as the decreased density of air with rising altitude and also the absorption of UV light by the ozone layer. At 39. 045 kilometers above the Earth, Felix was actually in the upper stratosphere where the atmosphere is very thin and cold, and WolframAlpha shows the temperature at such height is only about -14 degrees Fahrenheit (-25. 56__°C) on average. If that is seen warmer compared to the given subzero temperature we see at airliner altitudes (troposphere), that is because of the changes in temperature that increase slightly as going upward in the stratosphere. This is mainly due to energy trapping gaseous like ozone reside where the ozone molecules absorb energy from light coming from the Sun and that is actually what heats the sratosphere. By referring to Figure 2, it can be seen clearly that pressure decreases exponentially with increasing altitudes. There is a clear relationship of inversely proportional between the two parameters. At 39 kilometers away from Earth's surface where the distance settled at atmospheric layer called stratosphere, the air pressure is only 3. 3 millibars (as given by WolframAlpha). This value can be verified against automatic atmospheric properties calculator that basing on NASA model. As below is a hyperlink that jumps to the specified url of the calculator. Applying the automatic calculator by substituting the Felix's altitude would give values of atmospheric properties such as density, temperature, and pressure which are fairly close to that given by WolframAlpha. Therefore sending query to WolframAlpha can be seen as a highly reliable method to gather all the information that accurate. WolframAlpha predicts that the air pressure at Felix surrounding is only 3. 3 millibars. This is equivalent to 0. 33% of the air pressure at sea level which in turn means the rest of 99. 67% of the world's atmospheric pressure lay beneath him. This information is very crucial for Felix to exceed the speed of sound during free fall because rate of drag is related directly to air pressure. With only 0. 33% air around him, there would be less drag thus enabling Felix to reach the higher maximum speed than the speed of sound. At this point, Felix definitely must be fully-equipped with an oxygenated suit to allow him to breathe and keep him warm so that he could leap back to the ground alive and safe. One might assume that the drag on the falling Felix's body to be most negligible ast such a very low pressure, however as he speeds up very quickly, his velocity would be higher and higher thus increasing the drag effect.

e) Study the relationship between sound of speed and increasing altitudes

The fact that the speed of sound varies with altitude also helped us to investigate in depth of how Felix had go supersonic. At high altitudes, because of the cold and the low density of the atmosphere, sound will take longer time to travel. This is not a linear relationship, as the temperature of the atmosphere varies significantly with altitude, and also affects the speed of sound as clearly shown in Figure 3 below. The area of interest can be zoomed in with some short Mathematica code, by extracting the plot points and using interpolation method. This will bring us to a closer view at the relevant portions of Felix's jump downward to the Earth. By referring to Figure 4 above, there is a minimum value of sound speed in the middle of Felix's fall, which ideally gives a target for Felix to break the sound barrier. However, how easy to break the sound barrier is complicated to be explained and WolframAlpha can't yet tell us. So, what we need to do now is to find out by using Mathematica. There are two methods applied in the present work. The first one is by using iteration method that requiring Felix's acceleration, a to be calculated for every 10 seconds. As Felix went supersonic at about 40 seconds, therefore iteration will continue until 40 seconds time. The second method applied is basically solved through Mathematica to look at how Felix's speed has changed through his descent. By using this method, we might look at the maximum free fall velocity recorded by Felix and produce a smooth curve of Felix's velocity progression towards jumping to the Earth. Note that the second method used was executed separately using the new version of Mathematica 9. This is because after trying so many times with Mathematica 8, the coding or inputs does not seem to be working. Following this, therefore, intended readers should be aware of the different version of Mathematica used in the second part of modelling as it may have not been supported or may not function properly with the older version. The aim of introducing these two methods in the study is mainly to compare which of them is more reliable to give accurate result or fairly close to the official reports released. This in turn means to show how reliable Mathematica is in satisfying the objectives of the work. where v is Felix's velocity, Cd is the drag coefficient, A is maximal cross-sectional area, and ✕ is air density at altitude z. For value of A, this refers to the representative area of the falling body which in turn means to the aerodynamic surface area of the falling Felix. If Felix was rigidly upright and his body positioned headfirst during the freefall, this might be as low as 0. 1 square meters (assuming average shoulder width and body depth). Felix's position is crucial as positioning headfirst in a vertical dive will fall faster than a body falling in any other positon. But according to the official report, Felix did go into spin that might have increased his cross-sectional area to be lengthwise, therefore 0. 7 square meters, which equals to 0. 49 m2 seems to be a reasonable value to be considered into the calculation. Next, we need a value for a drag coefficient, Cd. An upright skydiver who was tumbling much of his fall usually experienced an estimated drag coefficient between 1 and 1. 3. Therefore, we should assume Felix ideally experienced the highest end of drag coefficient that is Cd = 1. 3 as he hits supersonic speeds within a very short period. Then, drag should also be taken into account once the body has started in motion, therefore we need a value for velocity, v. Let's allow for 10 seconds of free-fall at the previously calculated gravitational acceleration 9. 689 m/s2; v = t x a eq. (4)By using equation (5) below, the value of deceleration that cause the drag force can then be calculated. Fd = m x a eq. (5)Where in this case, a refers to the deceleration. So, the value of Fd is now availabe. The only variable that need to be work out is the mass of Felix. In the Red Bull Stratos page, they says that a fully loaded Felix Baumgartner (his bodyweight and equipment) is about 260 pounds, that is equivalent to 117. 934 kg. Therefore, substitute this value into equation (5) in order to get the value of deceleration, a. Therefore, Felix deceleration value is 0. 116624 m/s2 . Subtract this value from the gravitational acceleration gives us 9. 57238 m/s2 of Felix current acceleration after 10 seconds of free fall;

- Felix's Velocity at 40 seconds (using Iteration method)

Now, we need to compare this model with other varying estimates of Felix's velocity at the 40 second marks of free fall, so that we can determine the maximum velocity achieved by Felix within the short period. This means we need to reproduce this calculation until we get to the 40 seconds. For each iteration, we just need to adjust the acceleration, a in order to determine the new drag force for every 10s time increment, and the drag is itself affected by the velocity of a falling body. Felix deceleration value is 0. 460878 m/s2 . Subtract this value from the previous acceleration of 9. 57238 gives to 9. 1115 m/s2 of Felix current acceleration after 20 seconds of free fall. Then continue iterates for every 10s time increment until reach the 40 seconds. According to the drag equation, the net force acting on an object falling near the surface of Earth is defined as follow; Fnet = ma = mg(z) - 0. 5 Av2✕(z)Cd eq. (6)Rearrange equation (6) gives; mdv/dt = mg(z) - 0. 5 Av2✕(z)Cd eq. (7)At equilibrium, the net force is zero (F = 0), therefore; mg(z) = 0. 5 Av2✕(z)Cd eq. (8)As an object accelerates, the drag force acting on the object will be getting higher. However, at a particular speed, the drag force will be equal to the momentum of the object (force produced from gravitional pull applied to its mass). At this point, the falling object will decelerate slowly and continue falling downward at a constant speed called terminal velocity. The reason of why a falling object reaches a terminal velocity is because the drag force that resisting its motion becomes proportional to the square of its speed. Mathematically, terminal velocity is given as; v = eq. (9)Rearranging equation (7) will give equation as follow which depicts the velocity as a function of altitude; mvdv/dz = mg(z) - 0. 5 Av2✕(z)Cd eq. (10)From Figure 6, we can see that Felix's speed (in green) rapidly increases until it meets or exceeds the speed of sound (in purple) around 30000 meters. Then, divide his velocity by the speed of sound at that altitude in order to find his local

Mach number. By referring to Table 1, it can be seen clearly that the maximum velocity succesfully recorded by Felix in the first 40 seconds freefall was 364. 843 m/s. This is a definitely clear value exceeding the speed of sound of 340. 29 m/s, however, the model proposed of " iteration method" may seem too crude as only drag force was taken into account, neglecting terminal velocity factor that contributes to the changes of Felix's speed. As the result, this produces a less accurate value of maximum velocity calculated (364. 843 m/s) when compared to the official report of 372. 8 m/s. From Figure 6, there is a clear view that Felix's velocity has exceeded the speed of sound as well as the terminal velocity. As Felix approaches the speed of sound, he will experience more drag due to the higher amount of air flowing over his body. The air in front of his head is unable to move quickly around his body therefore becoming more and more compressed. This mixture of flow speeds will bring to dramatic changes in pressure and consequently would result in a violent loss of control to Felix. However, Felix managed to regain control when eventually the drag force balanced his weight and he finally reached terminal velocity. Breaking the speed of sound is a very challenging task. As skydivers are falling towards the Earth, they would speed up due to the gravity. But as they accelerates, the drag from the surrounding air reduces their acceleration until they reach terminal velocity and at this point, the drag should balance the gravitational force thus inhibit them to accelerate more. However, the amount of drag does depend on the density of the surrounding air. The more air flowing over the falling Felix, the higher the drag is. Since Felix will be jumping from the stratosphere of which the distance is much higher than the airlines altitude, and the air density is just less than 1% of that to the ground level, therefore his terminal velocity will be more than 277. 8 m/s and that is why Felix is still accelerating though has reached the terminal velocity (as referred to Figure 6). However, after reaching the outstanding maximum velocity, we realize that Felix has decelerated gradually as can be seen from Figure 6. At this point, the drag balances the gravitational (or weight) force, and Felix can accelerate no more, where he sudddenly started spinning and that could lead him to uncontrollable tumbling descent. Maximum speeds immediately reached up to 372. 8 m/s then Felix decelerated as the air thicken more and more at lower level of atmospheres. As Felix travelled down to the Earth, the air became more dense, thus slowing his speed of falling downward. Therefore, in overall, Figure 6 plotted by Wolfram predicts very well with phenomenon experienced by Felix. By referring to Figure 7, the maximum Mach number achieved by Felix is 1. 24. This value shows a very close agreement to the one officially reported which is 1. 24. Therefore, the second proposed modelling of producing a smooth curve using Mathematica 9 can be said as a highly reliable technique to be applied in the present work. By making assumptions on drag coefficient and surface area of the falling Felix, the first modelling of using iteration method produces less accuarate results when compared to the official report released. The significant of the deficiency of this modelling can be seen from the too crude method it applies of which calculating the acceleration and drag in increments of 10 seconds rather than producing a smooth curve. Nevertheless, this method shall give a basic idea on how a falling object is affected by air resistance. The second proposed modelling which applies

Mathematica to calculate Felix's velocity that changes through his descent is seen to be more accurate when the results produced agree very well with the official reports released, thus increases its realiability to be employed. This modelling produces a smooth curve of Felix's velocity progression, in line with terminal velocity and speed of sound. Following this, therefore gives a clear understanding to the intended readers on how Felix can go supersonic of 1. 24. As the conclusion, the second proposed modelling is chosen as the best method to be applied in future works and in overall, this work has proved that Mathematica is a very powerful tool that best fulfill the requirements and objectives of the work.