Space Jump

On 14 October 2012, Felix Baumgartner spent 2½ hours reaching the heights of the upper stratosphere with the aid of a Red Bull sponsored weather balloon, then spent the next 10 minutes getting back down.

One of the aims of the Red Bull Stratos project was for Felix to break the sound barrier by falling at more than $300ms^{-1}$ (the speed of sound at 30km altitude – it varies depending, primarily, on temperature).

Felix jumped from a height of $39045m$. At this altitude, the atmosphere is so thin that air resistance could be considered to be negligible. Assuming no air resistance, calculate the time required to reach a speed of $300ms^{-1}$ and the distance travelled in that time.

Since air resistance increases proportional to the square of the velocity, even for very thin air, it will have a measurable effect if the object is travelling very fast. In reality, Felix broke the sound barrier after 34 seconds. Assuming air resistance, and therefore acceleration, is constant throughout this time, find the magnitude of the acceleration and the distance he would have fallen.

Assuming Felix now accelerates at a constant rate of $4.55ms^{-2}$ for a further 16 seconds, calculate his top speed, and the altitude at which he reaches it.

Extension: If Felix had performed his little stunt on the moon, assuming he still dropped from $39045m$ and still pulled his parachute at an altitude of 1600m as he did on Earth, and taking acceleration due to gravity on the moon as $1.6ms^{-2}$, what would his top speed be?

Space Jump Solutions

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$$s=? \quad u=0 \quad v=300 \quad a=9.8 \quad t=?$$

$$v=u+at \quad \Rightarrow \quad 300=9.8t \quad \Rightarrow \quad \boldsymbol{t=30.6s\ to\ 3\ s.f.}$$

$$s=\frac{u+v}{2}t \quad \Rightarrow \quad s=\frac{300}{2}(30.6)=\boldsymbol{4590m\ to\ 3\ s.f.}$$

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$$s=? \quad u=0 \quad v=300 \quad a=? \quad t=34$$

$$v=u+at \quad \Rightarrow \quad 300=34a \quad \Rightarrow \boldsymbol{a=8.82ms^{-2}\ to\ 3\ s.f.}$$

$$s=\frac{u+v}{2}t \quad \Rightarrow \quad s=\frac{300}{2}(34)=\boldsymbol{5100m}$$

Assuming Felix now accelerates at a constant rate of $4.55ms^{-2}$ for a further 16 seconds, calculate his top speed, and the altitude at which he reaches it.

$$s=? \quad u=300 \quad v=? \quad a=4.55 \quad t=16$$

$$v=u+at \quad \Rightarrow \quad v=300+4.55\times 16=\boldsymbol{372.8ms^{-1}}$$

$$s=\frac{u+v}{2}t \quad \Rightarrow \quad s=\frac{300+372.8}{2}(16)=\boldsymbol{5382.4m}$$

$$\Rightarrow \quad Altitude=39045-5100-5382.4=\boldsymbol{28562.6m}$$

Extension: If Felix had performed his little stunt on the moon, assuming he still dropped from $39045m$ and still pulled his parachute at an altitude of 1600m as he did on Earth, and taking acceleration due to gravity on the moon as $1.6ms^{-2}$, what would his top speed be?

$$s=39045 \quad u=0 \quad v=? \quad a=1.6 \quad t=?$$

$$v^2=u^2+2as \quad \Rightarrow \quad v=\sqrt{2\times 1.6\times 39045}=\boldsymbol{353ms^{-1}\ to\ 3\ s.f.}$$

Note: parachute deployment is irrelevant; since there is no air resistance, the parachute would not slow him down at all and he would hit the surface at almost 800mph.