

Bungee Jump: Phases of motion

Figures shown are approximate, and based loosely on the Verzasca dam bungee jump from GoldenEye, ignoring loss of energy from the system due to air resistance, heat, transverse motion (in reality bungee jumpers end up swinging sideways, which reduces vertical speed).

Note: Displacement, velocity and acceleration values are given as positive in the downwards direction.

Beginning:

Displacement	Velocity	Acceleration	GPE	KE	EPE
0m (min) increasing	0ms ⁻¹ increasing	9.8ms ⁻² constant	160kJ (max) decreasing	0kJ (min) increasing	0kJ (min) constant

Phase 1 - Freefall: At the start, the jumper is stationary, and the cord is slack, so all energy is in the form of gravitational potential. The only force acting is his own weight, hence his acceleration is simply that due to gravity. During this phase, GPE is being converted directly to KE.

Cord becomes taut:

Displacement	Velocity	Acceleration	GPE	KE	EPE
95m increasing	43ms ⁻¹ increasing	9.8ms ⁻² decreasing	90kJ decreasing	70kJ increasing	0kJ (min) increasing

Phase 2 – Cord taut, still accelerating: At the instant the cord becomes taut, nearly halfway down, the jumper is travelling at around **90mph**, but he is still accelerating (albeit not as rapidly as when in freefall). Nearly half of the GPE has now been converted into KE, but during this phase GPE will go increasingly into EPE, meaning KE will not increase as fast as before. The resultant force will still be downwards, as the tension is not as great as the weight.

Max speed:

Displacement	Velocity	Acceleration	GPE	KE	EPE
130m increasing	47ms ⁻¹ (max) decreasing	0ms ⁻² decreasing	65kJ decreasing	80kJ (max) Decreasing	15kJ increasing

Phase 3 – Slowing down: Eventually the upward force of tension will exceed the weight, and his downward speed will begin to drop at last. From now on, energy is being transferred from both GPE and KE to EPE due to the increased tension in the bungee cord.

Lowest point:

Displacement	Velocity	Acceleration	GPE	KE	EPE
220m (max) decreasing	0ms ⁻¹ decreasing	-25ms ⁻² (min) Increasing	0kJ (min) increasing	0kJ (min) Increasing	160kJ (max) decreasing

Phase 4 – Bouncing back:

At the lowest point, all GPE and KE has been transferred to EPE. Since the cord is at maximum extension, the acceleration is now the greatest it will be at any point during the jump, but it is still acting in the upwards direction. However, since the jumper has lost all downward speed by this point, rather than falling downwards more and more slowly, he will begin travelling upwards faster and faster. The reverse journey is identical in all respects except the direction of velocity and acceleration. His maximum speed will be reached once again, for instance, at the same point (where tension equals weight, giving zero acceleration), but this time he will be travelling up instead of down. He should end up exactly back at the starting point with zero speed and a slack rope.

Note that due to the inefficiency of this system in real life (see disclaimer at the top!) a jumper won't quite reach their original height.