Rotating Bodies and Angular Momentum
Diving

Narrator:
So let's go back to the rotation of the human body combined with motion under gravity. Whether it's falling from the high board, or jumping from the spring board, a diver behaves like any other body.

Dave Cobner:
Well Judy, as we know, all bodies falling under the influence of gravity describe a parabolic flight path. The diver in the take-off in these scenes has a horizontal component to his velocity and a vertical component to his velocity. When those two components are combined, the centre of mass then describes a parabolic flight path. So in analysing diving technique in sports science we can look at the pathway of the centre of mass as one element of the dive and the rotation of the body around the centre of mass as the second element of the diving technique.

Judy:
So the motion of the diver can be modelled in two parts, the motion of the centre of mass executing a parabola and the rotation of the body about the centre of mass.

Dave Cobner:
That's right.

Narrator:
When the diver leaves the board, he's leaning forward, so there's a torque to start the rotation and give him angular momentum which is then conserved. This is true of any body when there's no external torque applied.

Mike Edge:
Divers' rates of rotation are controlled by the way that they adjust their body position in the air. Obviously all rotation is created at the point of take off, and once they're up there they've got something which they can't completely get rid of. And we go through three shape changes. One is the straight shape where the body is absolutely straight as it says, and that is the slowest rotating position. Second is the pike shape where the body's bent only at the hips, and you make as compact a shape as you can with that restriction. And the third and the fastest rotating one is the tuck shape where the body's bent at the knees and at the hips, and is bunched up as tightly as you can make it.

Judy:
OK Dave, so what's happening to the moment of inertia in those different positions?

Dave Cobner:
Well, the moment of inertia as we said earlier is the distribution of body mass around the axis of rotation. If we look at the divers in these pictures, in the right hand example, the handstand position shows the greatest distribution of mass that's possible. The body segments are as far removed from the axis of rotation that is possible; therefore you will get a very slow rotation. In the example on the left the diver has assumed a very tight tuck position, which will bring all the body segments as close to the axis of rotation and therefore maximise angle of velocity. In both types of dive the angle of momentum created will be conserved throughout the dive, angular velocity times moment of inertia will always equal the constant.

Mike Edge:
Rates of rotation change once you've left the board. You try and start with the slowest amount of rotation that you can which means you're gonna make your straightest lever, so

that when you change the shape from that long lever you will increase as much as you possibly can in as short as time as possible, so again when you want to slow down and make your entry into the water, by changing the shape back out to the slowest rotating one it gives you the most control over an entry.

Judy:
So, what happens when the diver hits the water?

Dave Cobner:
Well as we said, Judy, the angular momentum within the system is conserved so the diver is still turning as he or she hits the water. There's a great need to minimise the turning effect as the dive has been complete to allow a vertical entry. So the moment of inertia has to be restored at its maximum possible value.

Judy:
So straightening out does this?

Dave Cobner:
Yes. What the diver has to do is time the opening out to achieve the optimal entry position for the water. If the timing is wrong, in that the diver opens out too early or too late, then they will either under-rotate or more painfully over-rotate the dive. Once they've entered the water the resistance of the water provides a torque which will reduce the angular momentum in the system and stop the rotation.

Judy:
So, in order to start or stop rotation you need to apply a torque?

Dave Cobner:
Yes, that's right. And the rate of rotation is determined by the moment of inertia, and the concept of the moment of inertia has some very valuable applications in other sports as well.