"CAT TURNING" PHENOMENON

The physics behind cats landing on their feet, and how physics powers my fascination of cats

Elleanore P.
15 years old

How physics powers my love for cats!

Physics involved

Overall:

- **Dynamics –** the study of the relationship between the **motion** of an object and the **forces** acting on it.

In particular:

- **The moment of inertia –** an object's **"resistance"** to **angular acceleration** and depends not only on the object's **mass**, but also the **distribution of that mass** in relation to the **axis of rotation;** and
- **The angular momentum** - referred to as **spin**, is determined by an object's **mass**, its **velocity** and how far the **mass extends** out from the **point of rotation.**

Step 1

•1 – The cat determines its position using an apparatus in their inner ear called the vestibular system.

That enables the cat to quickly figure out which way is up and rotate its head facing down so the body can follow.

Step 2

•2 – The cat arches its back in order to split its body in two halves – each half will rotate around a different axis.

The cat's motion seems to imply a rigid body acquiring angular momentum, however, cats are flexible objects (they do not have a collarbone and have a super flexible backbone), ensuring they have a huge upper body rotation.

The cat "pushing off" part of its own body to rotate can be modelled as a pair of cylinders, with the back being bent to twist two separate sides of the cat.

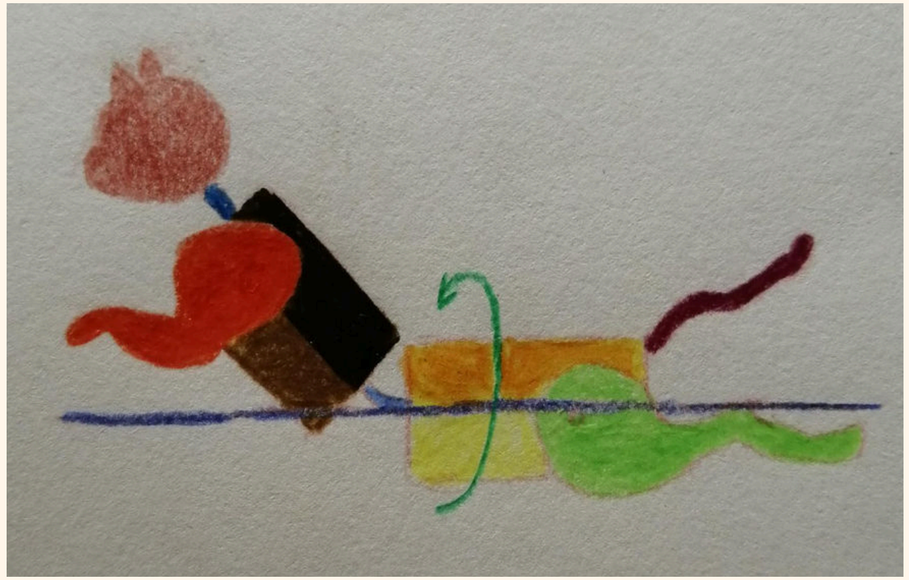
Step 3

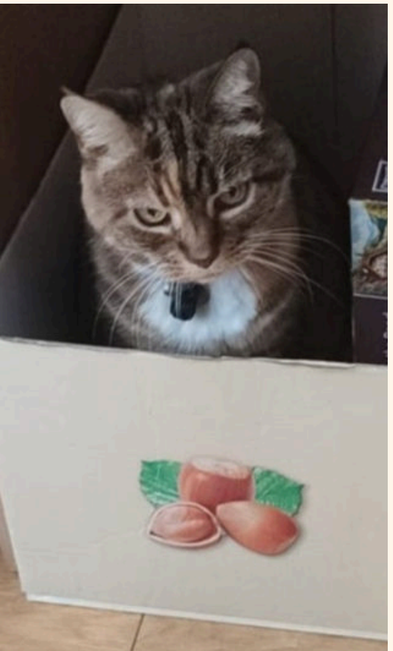
•3 – The cat tucks its front paws into its body close to its face, reducing the moment of inertia in the front half.

The cat continues to keep its hind legs extended to increase the moment of inertia by rotating the front half as much as possible, with the rear half being rotated in the opposite direction.

Step 4

•4 - The cat stretches its front legs and tucks in its hind legs to rotate its rear half and slowing down the rotation in the opposite direction.



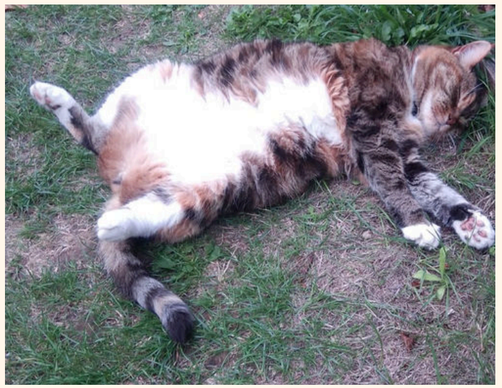


The cat's orientation changes from not on its paws to flipping onto its paws, but the angular momentum stays the same due to the front and hind parts bending towards each other and twisting in opposite directions around a central fulcrum. Therefore, the internal forces exerted cancel each other out.

Step 5

•5 - Depending on the situation, the cat might repeat some of the motions to complete a larger rotation before stretching its front and hind legs to slow itself down and land on its paws.

Landing on its paws, the cat's legs act like a compressed spring, meaning that the chest and then chin hit the ground, so sadly the cat wouldn't always land uninjured.



In summary...

Bend and twist

•Bend and twist – the cat bends at its waist to split its body in two and counter rotate each part. The parts act as each other's fulcrums, exerting an equal and opposite force and therefore the angular momentum stays the same.

Tuck and turn

•Tuck and turn like a figure skater – when the cat pulls its legs into its body, its rotational inertia around the same axis is reduced so increases its angular speed. When it stretches out its legs, the rotational inertia increases and slows down the cat's angular speed.

Conservation of angular momentum

•Due to the conservation of angular momentum, the cat can rotate its body and slow down its rate of rotation to land safely on all four paws.