WALK THE TIGHTROPE

Interactive Physics Simulation

To visit this simulation:

http://interactives.ck12.org/simulations/physics/walk-the-tightrope/app/
Intriguing Question

Why does a tightrope walker require a balancing pole?

Illustrative Video

Daredevils risk their lives walking along cables at dizzying heights. What might cause them to fall? How can they prevent falling? Why do they use balancing poles? Let's investigate the physics behind this. The force of gravity acts on all the parts of your body at once. We can think of the sum of these forces as acting from a specific spot: your center of gravity. If your center of gravity is above the cable, you won't pivot around the cable. If, however, you lean to one side, the torque generated by gravity will cause you to begin rotating, and eventually to fall. The balancing pole can help you adjust your center of gravity left and right. A bending balancing pole lowers the center of gravity. This reduces the moment arm of the gravitational torque for a given tilt angle. Importantly, the balancing pole also adds rotational inertia to the system. The walker and pole together will pivot more slowly if there is a higher inertia. Let's play around with these ideas.

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**Interactive Simulation**

**Balancing Pole Length** - This slider adjusts the length of the balancing pole, and thus its rotational inertia (moment of inertia). If you double the length of the pole, the inertia will quadruple - long poles really give you inertia, which gives you time to correct imbalances.

**Balancing Pole Mass** - This slider adjusts the mass of the balancing pole, and thus its rotational inertia and also the center of mass of the system. A higher rotational inertia (moment of inertia) gives the tightrope walker more time to adjust to imbalance. A lower center of gravity means there is a lower gravitational torque causing the walker to tilt - again, this helps give the walker time to adjust.

**Balancing Pole Stiffness** - A pole that is less stiff will be bent, and will have a lower center of gravity. A lower center of gravity causes the gravitational torque acting on the walker/pole system to be lower. This means the walker has more time to adjust to errors in balance.

**Initial Tilt Angle** - This slider allows you to 'throw the walker off balance' and see what happens. A high tilt angle means there is a strong gravitational torque causing the walker to rotate, and ultimately fall.

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Pole Rotational Inertia vs Pole Length - This is a plot of the rotational inertia of the pole vs. length. As you can see, the relationship is parabolic - the inertia is proportional to the square of the length of the pole. More mass farther out really helps with inertia.

Angular Acceleration vs Torque - This is a plot of the gravitational torque (horizontal axis) acting on the walker due to his tilt with respect to vertical compared to the angular acceleration (vertical axis) that results. When the rotational inertia of the system is greater, the angular acceleration is lower, giving the walker more time to adjust after errors.

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What type of balancing pole has the highest rotational inertia? (*Adjust the sliders to achieve the desired effect.*)

Under what conditions is the angular acceleration of the tightrope walker the lowest? (*Adjust the sliders so that the tightrope walker is as safe as possible - that is, so that his angular acceleration is least.*)

Under what conditions is the angular acceleration of the tightrope walker the highest? (*Adjust the sliders so that the situation is as possible - that is, the tightrope walker's angular acceleration is highest.*)

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**Challenge ME!**

Which combination of slider values gives the tightrope walker the most time to rebalance?

Which combination of slider values gives the tightrope walker the least time to rebalance?

Would doubling the length of the balancing pole double the amount of time the walker has? Or would it help even more than that?

**Need Help?**

Check out the Walk The Tightrope Walkthrough video at: [https://youtu.be/bk2VNm5TvGw](https://youtu.be/bk2VNm5TvGw)

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Interesting Questions

How does the balancing bird trick work?
The wings of the bird distribute its weight so the center of gravity of the system is actually directly below the point of contact with the pyramid. This means, from a torque and rotation perspective, this system acts like a pendulum - it returns to its original position with ease. It is in stable equilibrium rather than unstable equilibrium. A tightrope walker with a bendy-enough pole can achieve the same effect.

Which glass of water will most likely topple?
When you set an object on an inclined surface, a torque acts on it due to gravity. The system will be stable if the normal (contact) force between the object and the surface can generate a counter-torque. This is only possible if there is some part of the base of the object that is on the opposite side of the center of gravity. That is only true for one of these glasses shown here. The object with the higher center of gravity will topple.

Why do I put my arms out when trying to balance?
You are attempting to increase your rotational inertia and change the position of your center of gravity, so that you have more time to recover from a misstep and a smaller torque tilting you over. It is interesting, isn't it, how these physics concepts can arise so instinctually for us?

Why does a car go up “on two wheels” when it rounds a corner too quickly?
In order to stay on the road and turn, the frictional force acting between the wheels and the road must be very high. This frictional force points towards the center of curvature of the turn (some distance away). These frictional forces generate torques which rotate the car as well. These torques are counterbalanced by the normal force acting on the outside wheel. When the normal force required here is too high, the normal force on the inside wheel drops, and the car begins to lift upward. If the center of gravity passes over the point of contact between the wheel and the ground, the car will topple and flip over.

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Physics Concepts | Click on the link below to learn more.

- Torque - http://www.ck12.org/physics/Torque/

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