The weightless girl 1

(by Alan Champneys)

Some people say gravity is caused by the Earth's rotation. But a little thought shows that centrifugal force acts outwards not towards the ground. (Think of a wet dog spinning its body to throw off excess water).

Lauren, a girl of mass M, is standing on the equator where acceleration due Centrifugal force will make experience a weight that is slightly less than Mg. But how much less?

Some useful facts

- Centrifugal force $= mr\omega^2$, where r is distance to spin axis and ω is rotation speed in radians/s ($2\pi\times$ revs/s)
- The radius of the earth is 6371 km. The earth spins one revolution per 24 hours. g =9.81.

First, what is the earth's rotation speed in radians per second?

$\omega =$ revs/hour = rad/s

Hence calculate Laruen's centrifugal force as a function of her mass M. What percentage of her gravitational weight is lost due to centrifugal force?

centrifugal force = $\times M =$ % of Mg

The weightless girl 2

(by Alan Champneys)

So, the centrifugal force experienced by Lauren, standing at the equator, is about 291 times weaker than gravity.

Now imagine that the Earth was spinning faster. Centrifugal force increases with rotation speed, but gravity is unaffected. But how much faster would it to spin in order for Lauren to feel weightless. That is, is there a critical rotation speed ω_c for which centrifugal force exactly balances gravity.

The critical angular velocity (in radians per second) is

$$\omega_c = \qquad\qquad \text{rad/s}$$

which is times faster than the earth currently spins

How long would a day last on such a fast rotating Earth?

$$\text{day length} = \qquad\qquad \text{hours}$$