Q: A person weighs exactly 600.0 N at the North Pole. How much will they weigh at the equator. (Assume the Earth's radius is 6370 km at both locations.)

A: To find the person's mass, we sum the forces at the North Pole:

$$\Sigma F = F_g - F_N = 0$$

$$mg - F_N = 0$$

$$m = \frac{F_N}{g} = \frac{600\,\mathrm{N}}{9.81\,\mathrm{m/s}^2} \approx 61.14 \text{ kg}$$

This mass is a constant, so we can use this same value when we add up the forces at the equator. Note, however, that the sum of forces no longer equals zero since a point on the Earth's equator is accelerating.

$$\Sigma F = F_g - F_N = ma_R = m\frac{v^2}{R} = m\frac{\left(\frac{2\pi R}{T}\right)^2}{R} = \frac{4\pi^2 mR}{T^2}$$

The gravitational force between the Earth and the person has not changed and is still $F_g = 600 \text{ N}$. What we colloquially think of as weight, however, is really the force of contact, i.e. the normal force, between the person and the ground. Solving for F_N, we have

$$F_N = F_g - \frac{4\pi^2 mR}{T^2} = 600 \text{ N} - \frac{4\pi^2(61.14 \text{ N})(6.37 \times 10^6 \text{ m})}{(86400 \text{ s})^2} \approx \boxed{597 \text{ N}}$$

The person weighs only about 3 newtons less than they would at the equator. A difference of this magnitude could be measured accurately but would probably not be noticeable by the person.