Cheating the scales

or, how to lose weight by travelling

Data

$G = 6.674 \times 10^{-11}\ \mathrm{Nm^2kg^{-2}}$
Mass of Earth $= 5.976 \times 10^{24}$ kg
Polar radius of the Earth* = 6356 km
Equatorial radius of the Earth† = 6378 km

1) A typical grown man has a mass of about 80kg. For most Physics questions, what would you calculate his weight to be?

2) In fact, the value of *g* varies around the world because the Earth is not a perfect sphere. It is an *oblate spheroid*; rather fatter around the equator than around the Poles. Calculate the values of *g* at the Poles and at the Equator (*as always, be consistent with your significant figures*).

3) What would the weight of our 80kg man be at the Poles and at the Equator if we use these values of g? Calculate the difference between these values.

4) Mount Kilimanjaro in Kenya is over 5km high, and lies almost exactly on the Equator. What would the man's weight be if he climbed Kilimanjaro?

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* *i.e.* the distance from the centre of the Earth to the North Pole (it's more complicated for the South Pole: do you know why?).
† *i.e.* the distance from the centre of the Earth to any point at sea level on the Equator.

Your apparent weight can be affected by the Earth's rotation as well. Some of your weight is 'used up' in providing a centripetal force to stop you flying off into space. This doesn't mean your actual weight is less at the equator (any more than you are really weightless when in orbit around the Earth), but it would lower the reading registered by, say, a set of bathroom scales, just as an someone in orbit would register as weightless on a similar set of scales.

5) a) Where would a person require **no** centripetal force in order to stay on the Earth's surface?

b) Where would a person require **maximum** centripetal force to stay on the Earth's surface?

c) How would the centripetal force required change as they moved between the two points? (*try to say more than just "it would go up/down", e.g. "F would be proportional to…"*)

6) What centripetal force is required to keep an 80kg man in circular motion on the Earth's Equator? (*you will need to work out the speed of rotation of the Earth at the Equator*)

7) a) What would a set of bathroom scales read for the mass of an 80kg man at sea level at the equator? (*use your answer to q3*)

b) What would the same set of scales read for the same man on Kilimanjaro?

c) How much weight does he appear to have lost compared to his weight at the North Pole?