Double Centrifugal Force

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Abstract. **This article examines a situation in which two completely separate centrifugal forces are acting within a single rotating system. One centrifugal force relates to the rotation axis of the rotating system, while the other centrifugal force relates to the centre of the Earth and the horizontal transverse speeds within the rotating system. The latter has the power to cause an object to rise vertically in defiance of gravity.**

The Helicopter

I. When the rotor blades of a helicopter are not rotating, they tend to sag downwards. However, as soon as they start to rotate, they quickly lift up into the horizontal plane in defiance of gravity. The upward force is in part due to aerodynamical lift, but it is also in part due to the centrifugal force that is centred on the rotation axis. This centrifugal force acts outwards horizontally, but an upward component of it acts tangentially to the rotors, and this contributes to the lift, as in the case of the conical pendulum and the fairground ride known as the chairoplanes.

Modern teaching is against involving centrifugal force in the explanation of mechanical phenomena, and so every situation that involves centrifugal force is re-examined in order to find a way of explaining it alternatively using the inward acting centripetal force. In the example of the helicopter above, they would say that the upward force has been caused by a component of the tension in the rotor blades. Such an alternative analysis turns out to be mathematically correct, and so it is hard to argue against this alternative reasoning. It should however be noted that the tension in the rotor blades is a reactive tension that is actually caused by centrifugal force and gravity in the first place, and that no reactive force can ever exceed the action that is causing it. There is no vertically upward component of the centrifugal force, and the upward reaction against gravity cannot exceed the downward force of gravity. These facts call into question the rationale behind computing centrifugal effects using an induced tension that causes an inward centripetal force. It would nevertheless be convenient to find a demonstration of centrifugal force that isn't open to interpretation using centripetal force.

The Earth Centred Centrifugal Force

II. When a particle moves horizontally at the Earth's surface with a speed greater than 8km/sec, it will rise upwards. This follows from classical planetary orbital theory. In the radial planetary orbital equation, there is an outward term of the form $r\omega^2$ which acts in opposition to gravity. Because of conservation of angular momentum, it can take on an inverse cube law form l^2/r^3, where l is related to the angular momentum. Leibniz referred to this term as the centrifugal force, however nowadays the tendency is to avoid referring to this term as the centrifugal force, even though that is exactly what it is. In the special case of a circular orbit at the surface of the Earth, the centrifugal term can be written as v^2/R, where v is the transverse speed of 8km/sec and R is the radius of the Earth. This centrifugal term is clearly equal and opposite to the acceleration due to gravity at the Earth's surface. If the transverse speed increases above 8km/sec, the upward centrifugal term will then exceed the downward gravitational term, and the object will rise above the Earth's surface into an elliptical orbit. If the speed were to rise above the *escape velocity* of 11.2km/sec, the object would rise up and fly away in a hyperbolic path. It would continue to rise higher indefinitely.

This upward effect should also occur in respect of the horizontal motion of the rotor blades of a helicopter. The fact that they are constrained to move in horizontal circular motion should in no way diminish the Earth centred upward centrifugal effect given by v^2/R. Theoretically if the rotor blades of a helicopter were to rotate with transverse speeds in excess of 8km/sec, this should induced a levitational effect due to the Earth-centred centrifugal force, irrespective of any aerodynamical considerations. Furthermore, the higher the helicopter goes, the less is the horizontal speed required to generate an upward lift. There are of course impracticalities as regards having the rotor blades of a helicopter rotating at such high speeds, but nevertheless, planetary orbital theory predicts that centrifugal force should indeed cause a rotating object to undermine the downward effect of gravity. High above the atmosphere it would become much easier to test this effect, since the relevant transverse speed would be less, and there would be no obstruction caused by aerodynamical effects.