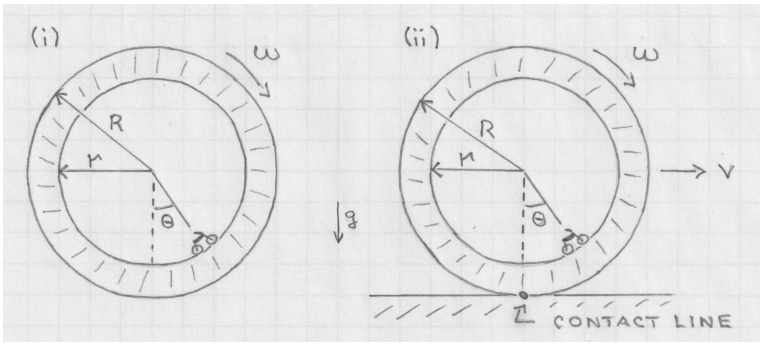
[mex282] Motorcycle treadmill

(i) A cylindrical shell of mass M, outer radius R, and inner radius r is free to rotate about its axis. A motorcycle of mass m (including easy rider) is observed to move along the inner surface at a constant angle θ as shown.
(a) Identify the nature of the three (balanced) forces acting on the motorcyle and sketch their direction in the xy-plane.
(b) Determine the angular acceleration $\dot{\omega}$ of the cylinder that makes the stationary angle θ possible. Express the result as a function of M, m, r, R, g, θ.

(ii) The same cylindrical shell is instead free to roll on a stationary horizontal floor. The motorcycle is again observed to move along the inner surface of the cylinder at a constant angle θ as the cylinder rolls to the right.
(c) Identify the nature of the three (unbalanced) forces acting on the motorcyle and sketch their direction and the direction of the resultant force in the xy-plane.
(d) Determine the acceleration $\dot{v}$ of the motorcycle relative to the floor that makes the stationary angle θ possible. Express the result as a function of M, m, r, R, g, θ.



Solution: