Effect of centrifugal & coriolis force due to earth rotation on acceleration due to gravity (g) on its surface.

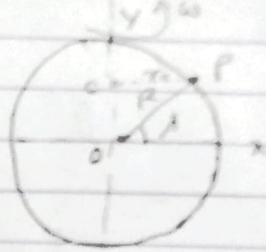
We know that acceleration $\vec{a}_s$ of a particle in inertial frame S is related with acceleration $\vec{a}_{s'}$ in non inertial rotating frame S' as.

$$\vec{a}_s = \vec{a}_{s'} + 2\vec{\omega} \times \vec{v}_{s'} + \vec{\omega} \times (\vec{\omega} \times \vec{r}) + \frac{d\vec{\omega}}{dt} \times \vec{r}$$

$$\vec{a}_{s'} = \vec{a}_s - 2\vec{\omega} \times \vec{v}_{s'} - \vec{\omega} \times (\vec{\omega} \times \vec{r}) - \frac{d\vec{\omega}}{dt} \times \vec{r} \quad \text{— (1)}$$

Let the particle is at rest

so $\vec{v}_{s'} = 0$ — (2)



Since earth rotates with constant angular velocity

so $\vec{\omega}$ = constant, $\frac{d\vec{\omega}}{dt} = 0$ — (3)

using (3) & (2) in (1)

$$\vec{a}_{s'} = \vec{a}_s - 0 - \vec{\omega} \times (\vec{\omega} \times \vec{r}) - 0$$

$$\vec{a}_{s'} = \vec{a}_s - \vec{\omega} \times (\vec{\omega} \times \vec{r}) \quad \text{— (4)}$$

$$\vec{g}' = \vec{g} - \vec{\omega} \times (\vec{\omega} \times \vec{r}_n) \quad \text{— (5)}$$

$$\vec{g} = -g\cos\lambda\,\hat{i} - g\sin\lambda\,\hat{j} \quad \text{— (6)}$$

$$\vec{\omega} = \omega\hat{j} \quad \text{— (7)}$$

$$\vec{r}_n = r_n\hat{i} \Rightarrow \vec{r}_n = R\cos\lambda\,\hat{i} \quad \text{— (8)}$$

using (6), (7) & (8) in (5)

(in $\triangle OCP$, $\frac{r_n}{R} = \cos\lambda$, $r_n = R\cos\lambda$)

$$\vec{g}' = (-g\cos\lambda\,\hat{i} - g\sin\lambda\,\hat{j}) - \omega\hat{j} \times (\omega\hat{j} \times R\cos\lambda\,\hat{i})$$

$$\vec{g}' = (-g\cos\lambda\,\hat{i} - g\sin\lambda\,\hat{j}) - \omega^2 R\cos\lambda\,\hat{j} \times (\hat{j} \times \hat{i})$$

$$\vec{g}' = (-g\cos\lambda\,\hat{i} - g\sin\lambda\,\hat{j}) + \omega^2 R\cos\lambda\,\hat{j} \times (\hat{k})$$

$$\vec{g}' = (-g\cos\lambda\,\hat{i} - g\sin\lambda\,\hat{i}) + \omega^2 R\cos\lambda\,\hat{i}$$

$$\vec{g}' = -(g\cos\lambda - \omega^2 R\cos\lambda)\hat{i} - g\sin\lambda\hat{j} \quad \text{--- (9)}$$

The magnitude of $\vec{g}'$ is given by

$$\vec{g}' = \sqrt{\{-(g\cos\lambda - \omega^2 R\cos\lambda)\}^2 + (-g\sin\lambda)^2}$$

$$\vec{g}' = \sqrt{(g\cos\lambda - \omega^2 R\cos\lambda)^2 + g^2\sin^2\lambda}$$

$$g' = \sqrt{g^2\cos^2\lambda\left(1 - \frac{\omega^2 R\cos\lambda}{g\cos\lambda}\right)^2 + g^2\sin^2\lambda}$$

$$g' = \left[g^2\cos^2\lambda\left(1 - \frac{\omega^2 R}{g}\right)^2 + g^2\sin^2\lambda\right]^{1/2}$$

$$g' = \left[g^2\cos^2\lambda\left(1 - \frac{2\omega^2 R}{g}\right) + g^2\sin^2\lambda\right]^{1/2} \qquad (1-x)^n = 1 - nx$$

$$g' = g\left[\cos^2\lambda\left(1 - \frac{2\omega^2 R}{g}\right) + \sin^2\lambda\right]^{1/2} \quad \text{--- (10)}$$

$$g' = g\left[\cos^2\lambda - \frac{2\omega^2 R\cos^2\lambda}{g} + \sin^2\lambda\right]^{1/2}$$

$$g' = g\left[1 - \frac{2\omega^2 R\cos^2\lambda}{g}\right]^{1/2}$$

$$g' = g\left[1 - \frac{1}{2} \times \frac{2\omega^2 R\cos^2\lambda}{g}\right]$$

$$\boxed{g' = g - \omega^2 R\cos^2\lambda}$$

For earth $R = 6.38 \times 10^6\,m$

$\omega = \frac{2\pi}{T} = \frac{2\pi}{24 \times 60 \times 60}$

$$g' = g - \left(\frac{2\pi}{24 \times 60 \times 60}\right)^2 \times 6.38 \times 10^8 \times \cos^2\lambda$$

$$\boxed{g' = g - 3.37\cos^2\lambda\ cms^{-2}}$$