Haversine Formular

① $a = \sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_1) \cdot \cos(\phi_2) \cdot \sin^2\left(\frac{\Delta\lambda}{2}\right)$

② $c = 2 \cdot \operatorname{arctan2}\left(\sqrt{a}, \sqrt{1-a}\right)$

↳ Means: f^n takes two arguments. (y, x)

③ $d = R \cdot c$

NB: arctan ⇒ $\tan^{-1}$

≠

④ radians = degrees $\times \frac{\pi}{180}$

Prob:

New York City - $(\phi, \Lambda) = (40.7128, -74.0060)$

London - $(51.5074, -0.1278)$

Sol^n)

① $\text{Deg}^\circ \rightarrow \text{rad}^c$:

Origin NY: $\phi_1 = 40.7128 \times \pi/180$

$= 0.710572$

$\lambda_1 = -1.291648$

Destination Lon: $\phi_2 = 0.898974$

$\lambda_2 = -0.00222$

SMK

(5) $\Delta \rightarrow$

$$\Delta\phi = \phi_2 - \phi_1$$
$$= 0.898974 - 0.710572$$
$$= 0.188402 \Rightarrow$$

$$\Delta\lambda = \lambda_2 - \lambda_1$$
$$= -0.000222 - (-1.291648)$$
$$= 1.289428 \Rightarrow$$

(8) $a = ?$

$$a = \sin^2\left(\frac{\Delta\phi}{2}\right) + \cos\phi_1 \cdot \cos\phi_2 \cdot \sin^2\left(\frac{\Delta\lambda}{2}\right)$$

$$= \sin^2\left(\frac{0.188402}{2}\right) + \cos(0.710572) \cdot \cos(0.898974) \cdot \sin^2\left(\frac{1.289428}{2}\right)$$

SIMK

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$= 0.00884761 + (0.757989)(0.62243) \cdot (0.361165)$

$= 0.00884761 + (0.471782) \cdot (0.361165)$

$= 0.00884761 + 0.170391$

$= 0.179239$

$a = 0.179239$

$c = 2 \cdot \tan^{-1} 2\left(\sqrt{a}^{(y)}, \sqrt{1-a}^{(x)}\right)$

$\sqrt{a} = \sqrt{0.179239}$

$= 0.423366$

$\sqrt{1-a} = \sqrt{1 - 0.179239}$

$= 0.905959$

$\Rightarrow \frac{y}{x} = \frac{\sqrt{a}}{\sqrt{1-a}} = \frac{0.423366}{0.905959} = 0.467312$

$\Rightarrow \tan^{-1}(0.467312) = 25.05°$

$25.05 \times \frac{\pi}{180} = 0.437157$

$\therefore c = 2 \cdot 0.437157 \Rightarrow 0.874314$

$d = r \cdot c = 6371 \times 0.874314$

$\Rightarrow 5570.254494$ km