# LAB 1 Report

Course:- FOUNDATIONS OF ARTIFICIAL INTELLIGENCE
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## Assumptions

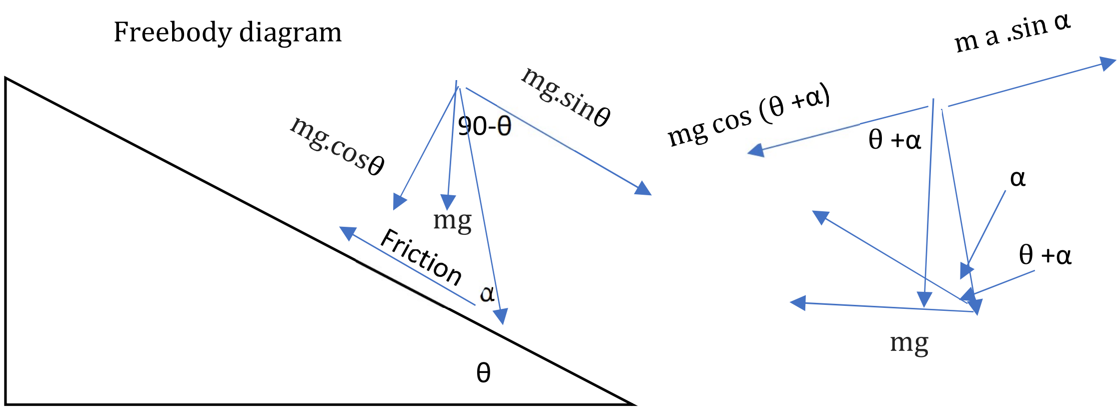
Assuming minimum time required to speed up to maximum speed from rest is 1 second. So maximum net acceleration(after considering air viscosity and friction)($a_{max}$) is $\frac{v_{max}-u}{t} = \frac{v_{max}-0}{1} = \frac{v_{max}}{1}$ and hence maximum force ($F_{max}$) the person with mass m can exert is $m\,a_{max} = \frac{m\,v_{max}}{1}$.

For all purposes, we assume we are supplying a maximum force, until $v_{max}$ is reached, or until net forces cancel out. We assume that water viscosity is not changing with temperature and only consider a constant swimming speed. We assume that the wind speed in different weathers do not affect the speed of the runner. We assume that the orienteer is not a mountain-climber. We don't assume the effect of buoyancy on the orienteer in case of walking in water. We consider height of a water body will be constant. Also there is no snow accumulation in winter and no rains in any season.

## Calculations

Average sprinting speed is 20-30km/hr (Source1), selecting 25km/hr which is 6.94 m/sec. Therefore, maximum acceleration is 6.94 $m/s^2$ Average swimming speed of a human is 2 mile per hour(Source2) i.e. 0.89 m/s.

Freebody diagram




Let F = m $a_{leg}$.

When in static equilibrium. (x & y are respective to ground surface)

$\sum \boldsymbol{F_y} = 0$

Normal Force = mg cos θ.

Frictional Force = μ x Normal Force = μ x (mg cos θ).

$\sum \boldsymbol{F_x} = 0$ (Adding fake force for accelerating frame of reference)

mg sin θ + Net Force = Frictional Force

mg sin θ + m $a_{net}$ = μ mg cos θ.

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$g \sin \theta + a_{net} = \mu (g \cos \theta)$

$a_{net} = g (\mu \cos \theta - \sin \theta)$. ... (1)

(Here $a_{net}$ would be just enough to maintain constant velocity)

**To avoid slipping condition let net torque about ankle equal to 0**. (Consider height of runner a h, where center of mass is from h/2 and height of ankle = 0) Friction passes through the pivot hence has 0 effect on the torque, while pseudo force ($-F_{net}$) and gravity both act at center of mass of the human body.)

$(mg \cos (\theta + \alpha))\, h/2 - m\, a_{net} \sin \alpha)\, h/2 = 0$

$g \cos (\theta + \alpha) = a_{net} \sin \alpha$

$a_{net} = g \cos (\theta + \alpha)/\sin \alpha$

$g (\mu \cos \theta - \sin \theta) \leq g \cos (\theta + \alpha)/\sin \alpha$

$(\mu \cos \theta - \sin \theta) \leq (\cos \theta \cos \alpha - \sin \theta \sin \alpha)/\sin \alpha$

$(\mu \cos \theta - \sin \theta) \leq (\cos \theta \cot \alpha - \sin \theta)$

$\mu \cos \theta \leq \cos \theta \cot \alpha$

$\cos \theta (\mu - \cot \alpha) \leq 0$

i.e. $(\cos \theta \geq 0$ and $\mu - \cot \alpha \leq 0)$ or $(\cos \theta \leq 0$ and $\mu - \cot \alpha \geq 0)$

i.e. $(\cos \theta \geq 0$ and $\cot^{-1} \mu \geq \alpha)$ or $(\cos \theta \leq 0$ and $\cot^{-1} \mu \leq \alpha)$

suppose (for an average body, since leaning depends of mass distribution so we take minimum lean range) we take a minimum of 35° while leaning forward and minimum of 80° (i.e. 180-80 = 100° from front) while leaning backward. i.e. $35° \leq \theta + \alpha \leq 100°$ i.e. $35° - \theta \leq \alpha \leq 100° - \theta$.

i.e. $(\cos \theta \geq 0$ and $\cot^{-1} \mu > 35° - \theta)$ or $(\cos \theta \leq 0$ and $\cot^{-1} \mu < 100° - \theta)$

Also, if the above conditions are not satisfied we change to the new speed such that

$v_{new}^2 = v_{parent/actual}^2 - 2 * distance\ travelled\ in\ the\ pixel * g * [\cos (\theta + \alpha)/\sin \alpha - (\mu \cos \theta - \sin \theta)]$

We use $v_{parent}$ if we are in the same terrain & $v_{actual}$ if we are going to a new terrain.

(Such that $\alpha$ = 35-theta)

In general, we assume speed $\alpha$ Coefficient of static friction of that terrain. We use maximum speed as the proportionality constant. 1.2 * k = 6.94, therefore k = 5.783 –we multiple this value by static coefficient to get speed in a terrain. i.e $k \times \mu = 5.783 \times \mu$.

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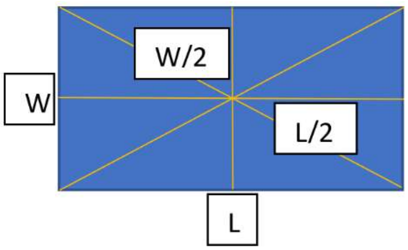
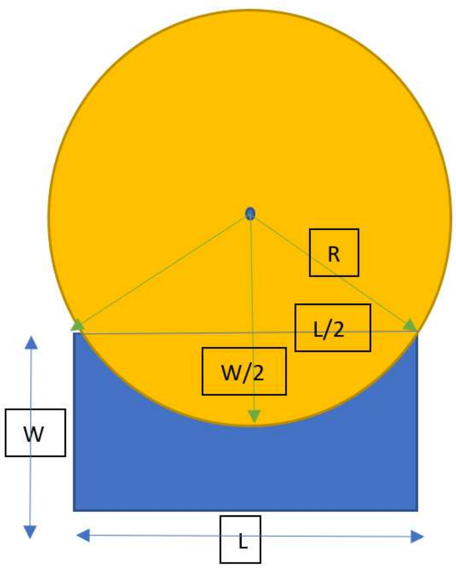
Distance Calculations:

For each case I assume we start from the middle.




For Most Terrain types(Except those involving a forest ) we take distance as the Euclidean distance, which is calculated as $(\frac{W}{2})^2 + (\frac{L}{2})^2 = (\frac{7.55}{2})^2 + (\frac{10.29}{2})^2 = 3.775^2 + 5.145^2 = 14.251 + 26.471 = 40.722$. Therefore, the answer is $\sqrt[2]{40.722} = 6.381$




For Forest Types we calculate distance considering there can be at most 4 obstructions (standing or fallen tree, shrub etc.) per pixel, one for each side. We consider that for

1) Easy Movement Forest the chance of that happening is ¼. So, we add ¼ of the excess distance from the normal case for an average case. (7.312)
2) Slow Movement Forest the chance of that happening is ½. So, we add ½ of the excess distance from the normal case for an average case. (8.244)
3) Walk Forest has 100% chance of needing to do that. (10.107)

Using Pythagoras's Theorem,

$$R^2 = (R - \frac{W}{2})^2 + (\frac{L}{2})^2 = R^2 - Rw + (\frac{W}{2})^2 + (\frac{L}{2})^2$$

$$Rw = (\frac{W}{2})^2 + (\frac{L}{2})^2 = 40.722 \text{ i.e. } R = \frac{40.722}{3.775} = 10.787$$

Length of the arc $= R\ tan^{-1}\left(\frac{R-\frac{W}{2}}{\frac{L}{2}}\right) = 10.787\ tan^{-1}\left(\frac{10.787-3.775}{5.145}\right) = 10.787\ tan^{-1}(1.362) = 10.107$

Final distance is calculated as

$$\sum \sqrt[2]{(distance\_for\_each\_terrain\_\&\_pixel^2\ x\ (no\ of\ cells\ travelled\ in\ x\ direction + no\ of\ cells\ travelled\ in\ y\ direction)^2) +\ change\ in\ height^2)}$$

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| Terrain type | Static Friction Coefficient (coefficients source) | Distance Calculations | Changes in seasons | | | |
|---|---|---|---|---|---|---|
| | | | Summer | Fall | Winter | Spring |
| Open land | 0.85 (Packed & oiled gravel) | 6.381 | | | | |
| Rough meadow | 0.45 (Grass) | 6.381 | | | | |
| Easy movement forest | 0.75 (Rock Crushed) | | | (2) | | |
| Slow run forest | 0.75 (Rock Crushed) | | | (2) | | |
| Walk forest | 0.75 (Rock Crushed) | | | (2) | | |
| Impassible vegetation | 0.00000001 (to make in impassible) | 6.381 | | | | |
| Lake/Swamp/Marsh (1) | 0.128 | 6.381 | | | (3) | (4) |
| Paved road | 1.2(New Sharp Portland cement) | 6.381 | | | | |
| Footpath | 0.8 (Travelled Asphalt or Tar) | 6.381 | | | | |
| Ice Path | 0.25 (Ice) | 6.381 | | | (5) | |
| Out of bounds | | 0.00000001(It should be 0 but instead we take a very small positive value) | | | | |

(1) For lakes/swamps and marsh I have found the adjusted frictional coefficient to give speed by doing 0.89/6.94 = 0.128.

(2) Reduce coefficient by 0.5.(Arbitrary change, since detecting speed(friction) when travelling on leaf-filled grounds is difficult).

(3) 7 pixels of ice layer formed near the edges, so we convert it to (5)

(4) Max of 15 pixels of water, such that it is atmost 1 m above water level, & as water level decreases, speed approaches that of $\mu$=0.8(Since it is the most common $\mu$). But if it is more than 1m for example a depression near the lake, we would $\mu$=0.128(same as that of water).

i.e. When water level diffn. $h_w$ less than 1 m, $Speed_{muddy\_water} = 5.783*(\mu_{lake}*h_w+0.8*(1-h_w))$

Otherwise, $Speed_{muddy\_water} = 5.783*\mu_{lake}$