SAFE RETURN DOUBTFUL: WEEK 5

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SUMMARY

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1. Navigation in 3D: planning a hike to Rose Hills
    - Using distance vectors
    - Accounting for elevation
    - Understanding *power*
    - **Navigation with a compass**...calculating the distance to an object.
2. Radio-glaciology measurements
    - Index of refraction, speed, distance, and time
    - Using exponentials, properties of exponentials
    - Attenuation length
    - Reflection coefficient

Navigation in 3D

We require several tools for navigation in 3D terrain.

- Review distance calculations in 2D (return to energy in a moment).
- Altitude and energy, $W = mgh$.
- Power: $P = E/t$. Power is energy divided by time.
- Establishing the distance to a far away object: triangulation.

WHAT IS THE HORIZONTAL DISTANCE TO THE WATER TOWER?

Figure 1: A map including Whittier College and Turnbull Canyon.

WHAT ENERGY IS REQUIRED TO CLIMB TO SOME ALTITUDE?

Energy required to ascend an altitude h:

$$W = mgh \tag{1}$$

- m: mass in kilograms
- g: $9.81\ \mathrm{m/s^2}$
- h: altitude in meters
- W: energy in Joules

Assume the elevation above sea level of the water tower is 500 meters. What energy is required?

Power is energy divided by time:

$$P = W/t \tag{2}$$

- P: power in Watts (1 Joule/second)
- W: energy in Joules
- t: time in seconds

Assume the energy derived from the prior exercise. Suppose the hike takes 2 hours. What is the power consumption to make the climb?

CORRECTION: WALKING ALSO REQUIRES POWER

What power is required for walking?

Table 7.5 Energy and Oxygen Consumption Rates[2] (Power)

Activity	Energy consumption in watts	Oxygen consumption in liters O_2/min
Sleeping	83	0.24
Sitting at rest	120	0.34
Standing relaxed	125	0.36
Sitting in class	210	0.60
Walking (5 km/h)	280	0.80
Cycling (13–18 km/h)	400	1.14
Shivering	425	1.21
Playing tennis	440	1.26
Swimming breaststroke	475	1.36
Ice skating (14.5 km/h)	545	1.56
Climbing stairs (116/min)	685	1.96
Cycling (21 km/h)	700	2.00
Running cross-country	740	2.12
Playing basketball	800	2.28
Cycling, professional racer	1855	5.30
Sprinting	2415	6.90

Figure 2: Human activities and power consumption.

WHAT POWER IS REQUIRED TO CLIMB TO SOME ALTITUDE?

Power is energy divided by time:

$$P = W/t \tag{3}$$

- P: power in Watts (1 Joule/second)
- W: energy in Joules
- t: time in seconds

Now add the power consumption to the climbing exercise: what is the total power consumption?

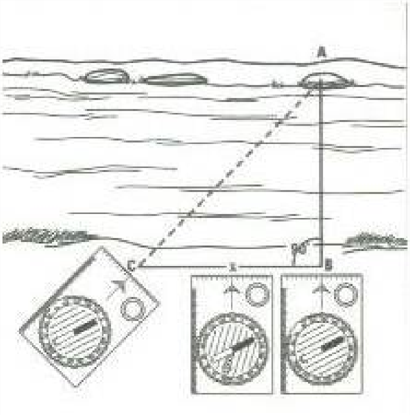

Figure 3: The basic idea behind parallax and distance determination.

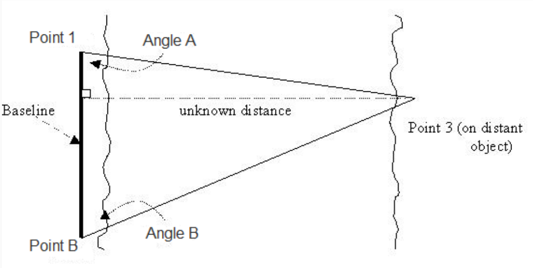

Figure 4: Using trigonometry to determine distance.

Let the unknown distance be called d. Further, let the baseline be called $b = b_1 + b_2$. We can show that

$$\boxed{d = \left(\frac{\tan(A)\tan(B)}{\tan(A) + \tan(B)}\right) b} \tag{4}$$

$$\boxed{d = \left(\frac{\tan(A)\tan(B)}{\tan(A) + \tan(B)} \right) b} \tag{5}$$

Suppose we want the distance to a far away mountain. We walk perpendicularly to the mountain after taking a compass *bearing* that tells us $A = 70$ deg. Our baseline is $b = 1000$ m. We find $B = 60$ deg after taking a new bearing. What is the distance d to the object?

Activity: What if we calculated the distance to Downtown LA by taking a bearing from Turnbull Canyon and the Science and Learning Center?

RADIO-GLACIOLOGY MEASUREMENTS

Index of refraction: the speed of radio waves is different in different materials.

$$v = \frac{c}{n} \tag{6}$$

- v: Actual speed of radio wave in material
- c: Speed of light, 3×10^8 m/s
- n: A number close to 1

Attenuation length: the length over which the radio wave *amplitude* decreases by a factor of e.

$$E = \frac{E_0}{r} \exp(-r/L) \tag{7}$$

- E: Observed radio wave amplitude
- E_0: Original radio wave amplitude
- r: The total distance traveled
- L: The *attenuation length*.

Observe example on board. Attenuation length varies with temperature.

REVIEW OF ATTENUATION LENGTH OF ICE