**The University of New Mexico**

**School of Engineering**

**Electrical and Computer Engineering Department**

**ECE 535 Satellite Communications**

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Module # 4: Problems 3.1, 3.3, 3.6, 3.7, 3.8, 3.9, 3.14, 3.15, 3.16

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3.1: Explain what is meant by the geostationary orbit. How do the geostationary orbit and a geosynchronous orbit differ?

* They both have an orbital period of 1 day ie 24 hours. They differ because geostationary is a circular orbit so it appears to not move in the sky at all when viewed from Earth. It also has zero inclination so it lies on the equatorial plane. Geosychrnous orbits can be elliptical, and have inclination as long as it has an orbital period of 1 day.

3.3 Determine the latitude and longitude of the farthest north earth station which can link with any given geostationary satellite. The longitude should be given relative to the satellite longitude, and a minimum elevation angle of 5° should be assumed for the earth station antenna. A spherical earth of mean radius 6371 km may be assumed.

* rs = 42157 km (GEO)
* el = 5 deg
* cos(θ\_max) = (RE / rs) \* cos(el)
* cos(θ\_max) = (6371 / 42157) \* cos(5 deg)
* cos(θ\_max) ~ 0.1511 \* 0.9962 ~ 0.1505
* θ\_max = arccos(0.1505) ~ 81.3 deg
* Maximum latitude = 81.3 deg
* Maximum relative longitude = 81.3 deg

3.6: An earth station is located at latitude 35°N and longitude 100°W. Calculate the antenna-look angles for a satellite at 67°W.

* rs = 42164 km
* lat = 35 deg
* lon\_e = -100 deg
* lon\_s = -67 deg
* delta\_lon = lon\_s - lon\_e = (-67) - (-100) = 33 deg
* lat\_rad = lat \* pi / 180 = 0.6109 rad
* delta\_lon\_rad = delta\_lon \* pi / 180 = 0.5760 rad
* cos\_beta = cos(lat\_rad) \* cos(delta\_lon\_rad) = 0.8192 \* 0.8387 = 0.6865
* beta = arccos(cos\_beta) = 0.813 rad = 46.56 deg
* R = sqrt(rs^2 + RE^2 - 2 \* rs \* RE \* cos\_beta) = sqrt(1.429e9) = 37810 km
* sin\_E = (rs \* sin(beta)) / R = (42157 \* 0.7257) / 37810 = 0.8088
* El = arcsin(sin\_E) = 54 deg
* sin\_delta\_lon = 0.5446
* tan\_lat = 0.7002
* cos\_delta\_lon = 0.8387
* tan\_beta = 1.0459
* denominator = tan\_lat \* cos\_delta\_lon - sin\_delta\_lon \* tan\_beta = 0.5873 - 0.5697 = 0.017
* tan\_A = sin\_delta\_lon / denominator = 0.5446 / 0.0176 = 30.95
* Az = arctan(tan\_A) = 88.15 deg

3.7: An earth station is located at latitude 12°S and longitude 52°W. Calculate the antenna-look angles for a satellite at 70°W.

* Since this is just the same steps as above here are the answers. Same for the following ones.
* Az: 255.44 deg
* El: 25.21 deg

3.8: An earth station is located at latitude 35°N and longitude 65°E. Calculate the antenna-look angles for a satellite at 19°E.

* Az: 334.76 deg
* El: 63.06 deg

3.9: An earth station is located at latitude 30°S and longitude 130°E. Calculate the antenna-look angles for a satellite at 156°E.

* Az: 153.32 deg
* El: 45.02 deg

3.14: (a) An earth station is located at latitude 35°N. Assuming a polar mount antenna is used, calculate the angle of tilt. (b) Would the result apply to polar mounts used at the earth stations specified in Probs. 3.6 and 3.8?

a).

* delta = 90-El-lat
* d=sqrt(6371^2+42164^2-2\*6371\*42164\*cos(35))
* d= 37125.46
* El=acos(42164/ 37125.46\*sin(35))
* El ~ 49.35deg
* delta = 90- 49.35-35
* delta = 5.65 deg

b).

* Yes, they would still apply but it would be using the Elevation and latitude of the specified problem

3.15: Repeat Prob. 3.14 (a) for an earth station located at latitude 12°S. Would the result apply to a polar mount used at the earth station specified in Prob. 3.7?

a).

* Same steps as before. Here are the intermediate values
  + d = 35956.63
  + El ~ 104.11 deg
  + delta = 90 - 104.11 - -12 = -2.11 deg

b). Yes, same result but we would just use the specified elevation and latitude angle

3.16: Repeat Prob. 3.14 (a) for an earth station located at latitude 30°S. Would the result apply to a polar mount used at the earth station specified in Prob. 3.9?

a). Same as before, here are the intermediate values

* d = 36784.74
* El ~ 124.97 deg
* delta = 90 - 124.97

b). Again yes, results will still apply just switch out the respective values.