San Bernardino Sheriff's Department
Basic Radar Training
Expanded Outline

MONDAY:

1. Orientation and Introductions

a. Instructor and class Introductions
b. Registration
c. Materials (Binder)

2. Radar History and Theory

a. Radar

RAdio **D**etection **A**nd **R**anging

b. Hertz

1. Heinrich Hertz 1887
2. Developed system to measure radio waves
3. 1920's and 1930's develop transmitter and receiver
4. 1940's World War II first useful radar system in use
5. Finding a target (Detection)
6. Calculating its distance (Range)

c. Doppler

1. Police Radar Development
2. Detects change in frequency waves (Doppler Frequency Shift)
3. Provides speed readings on a detected target (does not determine range)
4. Police radar does not detect range

3. Radar Operations

a. Function

1. Energy generated by transmitter
2. Antenna in a directional beam
3. Beam is in the shape of a cone
4. The beam is Reflected, Absorbed or Refracted
5. Beam strikes an object and is reflected to antenna
6. Small amount of beam bounces back to antenna
7. Antenna sends reflected beam to a receiver counter unit
8. Receiver shows target speed

b. Wave Concept

1. Radio Energy
2. Travels at the speed of light
3. Approximately 186,000 miles per second (constant)
4. Number of waves transmitted (police radar use preset frequencies)
5. Wavelength of radio (measured from top of one wave to the top of the next wave)
6. As the number of waves transmitted increase the length of wave decreases

7. As the number of waves decrease the length of the wave increases
8. One wave transmitted per second, length of wave is 186,000 miles
9. Radio transmitting 186,000 waves per second , wave length is one mile

4. Police Radar

A. Operates in microwave frequency band
B. Wavelength is very short
C. FCC assigned bands
1. X-band
a. Approximately 10.525 billion waves per second
b. 10.525 gigahertz
2. K-band
a. Approximately 24.15 billion waves per second
b. 24.15 gigahertz
3. Ka-band
a. Approximately 33.4 to 36.0 billion waves per second
b. Wideband Ka Radar hops between frequencies to defeat radar detectors
4. Frequency times the wavelength always equals 186,000 miles per second

D. Doppler Principle
1. Christian Johann Doppler
a. Austrian Physicist
b. Credited with discovering relative motion
c. Causes a signals frequency to change
2. Relative Motion
a. Between two objects, one transmitting wave energy
b. The frequency of the signal received by the other object changes due to relative motion
c. As objects get closer together the frequency will be increased
d. As objects get farther apart the frequency will be decreased
e. Frequency change is determined by the exact speed of the relative motion

3. Radar Beam
a. Cone Shape
b. Energy drops
c. Beam is infinite unless:
1. Reflected – signal is reflected back from oncoming traffic, signs etc.
2. Absorbed – signal can be absorbed into trees, hills covered with grass, etc.
3. Refracted – signal can be refracted from a large curved windshield or other surface where the signal is reflected off on an angle.
4. Beam Width
1. Depends on angle of beam (11 to 18 degrees)
2. 11 degrees
a. 50 feet wide at 250 feet
b. 100 feet wide at 500 feet
c. 200 feet wide at 1000 feet
3. 18 degrees
a. 80 feet wide at 250 feet
b. 160 feet wide at 500 feet
c. 320 feet wide at 1000 feet
4. Not lane selective
5. Not target selective

A. Stationary Radar

1. Radio waves strike motionless object
    a. No relative motion
2. Object moving toward radar source
    a. Waves shorten
    b. Frequency increases
3. Object moving away from radar source
    a. Wave lengthened
    b. Frequency decreases
4. Change in frequency
    a. Doppler Shift
    b. Measures objects speed
5. X-band
    a. Increase of 31.4 waves per second
    b. Equals 1 mile per hour
    c. 314 waves per second equals 10 mile per hour
    d. 3140 waves per second equals 100 mile per hour
6. K-band
    a. 72 waves per second equals 1 mile per hour
    b. 720 waves per second equals 10 miles per hour
    c. 7200 waves per second equals 100 miles per hour

B. Stationary Radar Cosine Effect

1. Position of radar angle to approaching vehicle
2. Difference between measured speed and true speed
3. Larger angle, lower measured speed
4. No speed measurement at a 90 degree angle

C. Radar Effects (Ghost Readings)

1. External Mechanical Interference
2. Interference inside the patrol car
3. RFI interference
    a. Via power and antenna leads
    b. CB radio
    c. Police radio and cell phones
    d. Lights
    e. Power lines
4. Own speed capture
5. Feedback
6. Windshield / AC fan
7. Panning
8. Batching
9. Shadowing

B. Moving Radar

1. Patrol vehicle speed obtained relative to ground
2. High Doppler
    a. Signal sent out is reflected back to antenna at a higher rate of speed
3. Low Doppler
    a. Signal returns to antenna has gone through a smaller frequency change
    b. Bounces off surrounding terrain

C. Moving Radar Cosine Effect
1. Can be for or against the violator
2. Antenna alignment
3. Oncoming vehicles produce angle
4. Curve in roadway
5. Improper low speed reading, will increase target vehicle's true speed
6. False Low-Doppler readings
    a. Wet and icy roadways
    b. Large buildings
    c. Reflective objects

D. Common Errors
1. Antenna positioning
2. Look-Past
3. Vehicle Interference
4. Cosine
5. Double-Bounce
6. Beam Reflection
7. Road-Signs
8. Radio Interference
9. Fan Interference

Tuesday:

5. Tracking History

1. A list of necessary elements in radar enforcement
    a. Visual Observation
    b. Doppler Audio
    c. Confirm
    d. Target within operational range of radar
    e. Patrol speed verified by speedometer
    f. Identify Target
    g. Estimation of target speed
    h. Confirm estimated speed with radar display

6. Radar Calibration & Maintenance

1. Check Calibration Readings
2. Accuracy Check
3. Self-Test
4. Tuning Fork
5. General Maintenance

7. Radar Math

1. Unit Moving
    a. CS-PS = TS
    b. Closing Speed – Patrol Speed = Target Speed

2. MPH to FPS
    a. 5280 feet in one mile
    b. 3600 seconds in one hour
    c. 5280/3600 = 1.467 fps
    d. FORMULA: fps = mph x 1.467

2. Stopping Distance
    a. Dt = Total stopping distance (includes perception, reaction, and braking time)
    b. S = Pre-braking speed of vehicle (MPH)
    c. Tpr = Time to perceive and react (seconds)
    d. f = friction value of roadway
    e. FORMULA: $Dt = (s \times 1.467 \times Tpr) + [S^2 / (30 \times f)]$

3. Distance Moving
    a. D = Distance vehicles were apart
    b. S_1 = Average speed of target vehicle
    c. S_2 = Average speed of patrol vehicle
    d. T = Time in seconds vehicles traveled
    e. FORMULA: $D = [(S_1 + S_2) \times 1.467 \times T]$

4. Cosine – Indicated Speed
    a. Is = Indicated Speed (Radar Speed)
    b. Ts = True Speed (Actual Speed)
    c. Cos L = Cosine of the approximate angle
    d. FORMULA: Is = Ts x (Cos L)

5. Cosine – True Speed
    a.Ts = True Speed (Actual Speed)
    b. Is = Indicated Speed (Radar Speed)
    c. Cos L = Cosine of the approximate angle
    d. FORMULA: Ts = Is / (Cos L)

6. Radar Beam Width
    a. Bw = Width of radar beam at a given distance
    b. D = Distance of vehicle from radar device
    c. Tan (1/2 Angle) = Tangent value of one half of the radar's beam angle
    d. FORMULA: Bw = 2 x D X Tan (1/2 Angle)

8. California Vehicle Codes

1. CVC 40800
    a. Vehicle and Uniform
    b. Division 10 or 11 of the Vehicle Code

2. CVC 40801
    a. Speed Trap Prohibition
    b. Participation Prohibited

3. CVC 40802
    a. Speed Trap Defined
    b. Speed Survey (5 years)
    c. Prima Facie Speeds

4. CVC 40802 (c)(1)
    a. Speed Traps
    b. Speed Survey (7 years)

5. CVC 40803
    a. Speed Trap Evidence

6. CVC 22348
    a. Highway with posted speed limit
    b. Speed greater than 100 mph

7. CVC 22349
    a. Maximum Speed Limit

8. CVC 22350
    a. Basic Speed Law

9. CVC 22351
    a. Basic Speed Law on a Highway

10. CVC 22352
    a. Prima Facie Speeds

9. Case Law

Related Case Law Updated Continually

10. Practical Application

1. Traffic Stops

2. Unit Positioning
    a. Officer Safety Issues

3. Safety Concerns
    a. Safety of the Violator

11. Court Preparation and Testimony

- Court Do's and Don'ts
- Violation Elements
- Personal Court Books
- Mock Trial

WEDNESDAY:

11. Speed Estimations

a. Examples of how to Estimate Speeds
b. Stationary
c. Moving

12. In Field Practical Application

a. Each student must estimate speed of moving vehicles
b. Visual Estimation
c. Confirm Speed with Radar Unit

13. Speed Estimation Test

a. Each student must successfully estimate the speed of 10 vehicles
b. Radar Unit Stationary
c. Radar Unit Moving

14. Summary Open Discussion

- Recap Course
- Open Discussion on Related Topics

Test Preparation

Final Exam

Course Evaluations

Certificates