1. (20 points) A target's position at time $t = 0$ is bivariate normal with $\sigma_x = \sigma_y = 3$ nautical miles (nm), centered about datum (0,0).

a. At time $t = 0$, what is the probability the the target is within 5 nm of datum?

b. At time $t = 0$, what the the mean distance from the target to datum?

c. At time $t = 0$, what is the most likely distance from the target to datum?

d. At time $t = 0$, the target begins fleeing north at a speed of 20 nm/hour (knots). After fleeing for 1 hour, set up the integral to evaluate the mean distance from the target to datum.

e. What is the answer to part d. if the target's fleeing course was uniformly distributed between north and east?

f. What is the answer to part d. if the target is fleeing radially from datum?

2. (20 points) A marine is manually sweeping a mine field with a sensor which detects 80% of all mines within a 1 meter detection range. He walks at 5 meters/minute while sweeping. He must clear a lane with a total area of 500 meters^2.

a. If the sweeper attempts to conduct exhaustive search with a track spacing of 2 meters, how long will it take him to conduct one sweep of the 500 meter^2 lane?

b. After that sweep, what is the expected fraction of the mines remaining in the lane?

c. What is the expected fraction of mines remaining after 3 independent sweeps of the lane?

d. How many independent sweeps are required to reduce the expected fraction of mines remaining to below .001?

e. If there were 10 mines originally in the lane, and the marine sweeps the lane four times. What is the probability that all 10 mines are detected?

3. (20 points) Answer each question true (T) or false (F).

( ) Assuming a uniformly distributed target, mean time to initial detection assuming random search is twice that of exhaustive search.

( ) When conducting random search for a target known to be in area A, it is not necessary to assume a particular target distribution over A to obtain probability of detection.

( ) In the $(\lambda - \sigma)$ model, the cumulative probability of detection increases as λ increases.

( ) The continuous looking detection rate model always gives a 0 probability of detection at time 0.

( ) The continuous looking model always gives a probability of detection of 1 as t increases to infinity.

( ) When searching an <u>expanding disk</u> using random search, eventual detection is certain.

( ) Using the ROC methodology, it is possible to achieve probability of detection (P_d) of 1, if an associated probability of false alarm (P_f) of 1 is acceptable.

( ) Detection is certain along tracks with lateral ranges (CPA ranges) strictly less than half the sweep width.

( ) When conducting random search with constant detection rate γ, the probability of receiving no detections during a time interval of length t is $e^{-\gamma t}$.

( ) When conducting random search with constant detection rate γ, the probability of receiving exactly 1 detection during a time interval of length t is $\gamma t e^{-\gamma t}$.

4. (20 points) The mean signal excess of an acoustic signal is -1.5 db. Use the $\lambda - \sigma$ acoustic detection model with $\lambda = .4$ jumps/minute and $\sigma = 3$ db.

a. What is the probability that the initial detection occurs before 5 minutes? (Note: $\Phi(-.5) = .3085$.)

b. What is the mean time to detection?

c. What is the mean time to detection given no detection at time 0?

d. What is the probability of a detection at time 0?

5. (20 points) A target submarine with speed 10 knots and searcher submarine with speed 10 knots are moving at random in a search area of size 100 nm^2. The searcher has a 2 nm detection range on the target.

a. Use random search with "dynamic enhancement" to estimate the probability of a detection by 2 hours of search.

b. What is the mean time to detection?

c. Answer a. and b. if only half of the target patrol area is inside the search area. Assume the "fast target" model.