BIOE 521 – answer all questions
BIOE 440R – answer questions 1- 4, 6, and either 7 or 8.

Modify the R scripts you have worked with to analyze the data in the life table below and implement a stochastic Leslie matrix projection to estimate extinction risk, and to implement a count-based PVA using the data in question 8.   For answers you calculate in R, paste your code and output into this document along with your written and graphical answers. You do not have to use R for every question but you can.

Age in years x	Number Alive N_x	Fecundity m_x	Survivorship from birth l_x	Annual survival s_x
0	100	0		
1	80	0		
2	64	0.6		
3	51	1.09		
4	31	0.2		
5	10	0		
6	0	--		

1. Complete the life table.

2. Ignoring the effects of the population's age structure, ignoring the effects of variance in the birth and death rates, and assuming that the population is growing exponentially, what is the expected population size in ten years? Show your work.

3. Show the survivorship curve (on a log-linear plot) for this population and briefly describe patterns of age-specific survival in this population.

4. (A) Show the Leslie matrix (with F_x simply equal to m_x values; no correction is required).
   (B) With this Leslie matrix, and using the N_x values from the life table as your initial population, determine total population size after 4 years (assuming deterministic growth, so that you can ignore variation in the birth and death rates for now).

5. The data in the life table above already account for juvenile survival, because they were collected with continuous population monitoring. In this case, you do **not** have to convert fecundity values before putting them into a Leslie matrix. However, explain how you would calculate fecundity (F_x) values for a Leslie matrix in a situation with data collected using a **post-breeding** census, and explain the logic of this adjustment.

6. (A) Show the expected stable age distribution for this population. Recall that this distribution can be obtained with the pop.projection() function of the popbio package, after you have created the Leslie matrix.
(B) Using the raw data in part 1, determine the *actual* age distribution of this population.

Age	Stable age distribution (% of population)	Observed age distribution (% of population)
0		
1		
2		
3		
4		
5		

(C) Compare the stable age distribution to the actual distribution – making the comparison *graphically* would reveal the similarities and differences most clearly. What does this comparison suggest about stability (or lack of stability) in the population's birth and death rates in recent years?

7. Run a stochastic projection of population growth over 20 years using the Leslie matrix (with a binomial distribution for survival probabilities and a Poisson distribution for fecundities). Start with a population of 100 individuals that has the same age distribution as in the original data. Show and briefly explain your output, including confidence limits for your projected final population size.

8. Using the set of lion counts in the table below, use a count-based PVA approach to estimate
   (A) the arithmetic mean annual growth and the geometric mean annual growth, and
   (B) the probability that population size will drop below 100 within the 20 years after 1982.
   (C) Given your answer to part A and part B, briefly explain why a population whose mean growth rate is positive can still have a substantial risk of extinction (pseudo-extinction, in this case)?

Year	Lion Count
1963	109
1964	125
1965	222
1966	189
1967	250
1968	165
1969	150
1970	147
1971	132
1972	250
1973	229
1974	323
1975	250
1976	124
1977	209
1978	138
1979	144
1980	149
1981	173
1982	186