



Subject: SRM - 1

Chapter:

**Category: Assignment
Questions**

1. A new insurance company launched certain insurance products in 2015. As this was a new line of business for it then, it has been using the standard mortality table rates to price its product and continues to do so since then. Over the years, it has gathered mortality claims data on its business, which can be used to set its future mortality assumptions. However, the products team is insisting on keeping the mortality assumptions unchanged (same as used since 2015) to price its new products. The Chief Actuary has asked to perform an analysis and validate the suitability of these standard rates.

The table below summarizes the experience analysis numbers from the policies sold by the insurance company and the standard mortality rates it has been using so far

Age group	Central exposed to risk	Number of Deaths in the sample	Standard mortality rate used
20-24	56655	80	0.000937
25-29	61220	78	0.000934
30-34	64908	80	0.001042
35-39	62052	85	0.001358
40-44	58751	120	0.001969
45-49	54900	150	0.003168
50-54	48679	295	0.005550
55-59	41699	366	0.008925

i) Carry out Chi square test at 5% confidence interval to check whether the underlying mortality for the insurer is same as the standard mortality rates.

ii) Based on (i) above, state your recommendation.

2. A large life insurance company has been selling term assurance plan for number of years and has carried out a mortality investigation for the first time recently. Mr. Bimankak, the company's Appointed Actuary is generally satisfied with the results and has recommended that the mortality rates obtained be used for setting mortality assumptions in the future. However, Mr. Bimankak has also suggested that the crude rates from the investigation are 'smoothed' before using them in actuarial calculations. He has sought your opinion on the appropriate method for graduation.

Briefly describe three methods of graduation that can be used, stating clearly the advantages and disadvantages of each as relevant to the insurance company. [9]

3. A specialist insurer sells only term assurance policies through a number of banks. It has collected claims data from last ten years of operations and this is provided below.

The insurer wishes to use the mortality rates based on its own experience for valuation purposes and also for pricing any new products in the future.

Age group [Age last birthday]	Initial exposed to risk	Number of deaths	Crude mortality rates
20-24	74	1	1.3514%
25-29	5,982	12	0.2006%
30-34	27,839	65	0.2335%
35-39	35,487	124	0.3494%
40-44	40,859	156	0.3818%
45-49	39,850	220	0.5521%
50-54	34,859	189	0.5422%
55-59	29,349	210	0.7155%

You have been asked to determine a set of graduated rates from the crude estimates provided above for use by the insurance company.

A graduation has been carried out and you are provided with the following graduated rates:

Age group [Age last birthday]	Graduated mortality rates
20-24	0.1515%
25-29	0.2089%
30-34	0.2731%
35-39	0.3442%
40-44	0.4223%
45-49	0.5075%
50-54	0.6000%
55-59	0.7000%

The Appointed Actuary is concerned that individual bias may have led to the rates being either under- or over-graduated.

a) Discuss the actuary's concern.

Clearly state the null hypothesis and carry out the chi-square in conjunction with another appropriate test to determine whether or not the crude rates are under- or over-graduated. (10)

b) Comment on your conclusions from part (ii) and the appropriateness of using the chi-square test in this case. (3) [19]

4. i) List the methods of graduation. Describe how smoothness is ensured when mortality rates are graduated using each method? (3)

ii) Explain why a mortality experience would need to be graduated. (2)

An actuary has conducted investigations into the mortality of the following classes of lives:

I. Members covered under PMJJY (Pradhan Mantri Jeevan Jyoti Bima Yojana)

II. Female population of a large developing country

III. Patients suffering from brain cancer in a small province.

The actuary wishes to graduate the crude rates for each of the above classes of lives

iii) State an appropriate method of graduation with rationale for each of the three classes of lives and, for each class, briefly explain your choice. (3)

A large life insurance company has graduated the mortality experience of a business portfolio. The original data and the graduated rates are as follows

Age	Exposed to risk	Number of deaths	Graduated Rates
50	1280	4	0.00230
51	2030	5	0.00262
52	1950	11	0.00296
53	2160	7	0.00331
54	2480	10	0.0037
55	1455	7	0.00415
56	2100	11	0.00463
57	1865	17	0.00518
58	1990	16	0.00578
59	1725	9	0.00645

iv) Test the graduation for overall goodness of fit. (4) [12]

5. As part of the exercise to price a group insurance scheme, a large Life Insurance Company has undertaken to investigate the mortality rate of the employees engaged in a hazardous occupation. The following is an extract from the exercise.

It was decided to graduate results with reference to the standard mortality rate of an assurance table published by the actuarial institute using a formula

$$q_x^o = 2 * q_x^s.$$

The q_x^s is the standard mortality rate. The standard mortality rates from the assurance table for the average ages are given below:

Age	23	28	33	38	43	48	53	58
Mortality rate	0.0011	0.0012	0.0013	0.0018	0.0027	0.0045	0.0075	0.0115

- (i) Explain the terms “Undergraduation” and “Overgraduation”. (2)
- (ii) Using a test of the overall fit of the graduated rates to the data, test the hypothesis that the observed mortality rates are in accordance with the graduated rates as per the formula given above. (6)
- (iii) Test the graduation using two other tests i.e. signs test and grouping of signs test. For each test:
- State the feature of the graduation it is designed to detect.
 - Carry out the test.
 - State your conclusion. (6) [14]

6. State the two factor Lee-Carter model. Define all the parameters and state the two constraints used while estimation. [5]

7. i) Give four important reasons as to why the crude mortality rates needs to be graduated.

ii) Graduation of mortality rates was done as per the following table. Find range of “p’ with appropriate explanations, such that 99% confidence interval is reached as per Chi-square test.

Age x	Exposed to Risk	Observed deaths	Graduated mortality rates
35	5444	80	0.01658
36	5355	102	0.01787
37	5268	88	0.01894
38	5197	110	0.01988
39	4978	91	0.02022
40	4831	106	0.02154
41	4654	123	0.02365
42	4521	107	0.02811
43	4487	122	0.02957
44	4321	125	0.03069
45	4101	140	0.03081
46	4021	145	0.03166
47	3951	140	p

iii) State four other types of tests that may be used other than Chi-square test for goodness of fit.

iv) State two disadvantages of Age-period-cohort model.

8. i) Explain what is meant by graduation and the aims of graduation (2)

ii) Explain the three desirable features of graduation (1)

iii) Describe what is meant by 'over-graduation' and 'under-graduation' (2)

iv) In one of the mortality studies, the crude mortality rates have been fitted by using the below equation

$$q_x = A \exp(-B * x) + \frac{CD^x}{1 + CD^x}$$

Where q_x is the probability of a person aged x dying before age $x+1$ and A, B, C, D are parameters that were estimated by least squares.

The parameters were estimated separately for males and females and are as given below

Parameter	Male	Female
A	0.00119	0.00012
B	0.86895	1.83524
C	0.00012	0.00007
D	1.08145	1.08175

Below are the crude mortality rates observed at certain ages

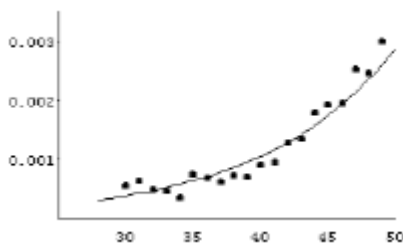
Age	Male	Female
20	0.00569	0.00337
25	0.00794	0.00468
28	0.01106	0.00651
33	0.01541	0.00904
66	0.02151	0.01255
71	0.02998	0.01744

For the above ages, derive the graduated rates using the formula given above (4)

v) Perform an overall test of the graduation process and comment on the appropriateness of the graduation. (3) [12]

9. How is mortality projected by expectation method?

10. i) Define the type of graduation in the figure below: (1)



ii) How do you test smoothness while performing graduation? (3)

iii) State the disadvantages of the Chi-Square test as a test of a mortality experience. (3)

iv) List one test that does not require making any assumption while testing for mortality experience. (1) [8]