MATH 3631
Actuarial Mathematics II
Final Examination
Tuesday, 7 May 2019
Time Allowed: 2 hours (1:00 - 3:00 pm)
Room: AUST 105
Total Marks: 120 points

Please write your name and student number at the spaces provided:

Name: ______________________________ **Student ID:** ______________________

- **There are twelve (12) written-answer questions here and you are to answer all questions. Each question is worth 10 points. Your final mark will be divided by 120 to convert to a unit of 100%.**
- **Please provide details of your workings in the appropriate spaces provided; partial points will be granted.**
- **Please write legibly.**
- **Anyone caught writing after time has expired will be given a mark of zero.**
- **Good luck to everyone. Congratulations, and all the best, to those graduating.**
- **Be safe and enjoy the summer!**

Question	Worth	Score
1	10	
2	10	
3	10	
4	10	
5	10	
6	10	
7	10	
8	10	
9	10	
10	10	
11	10	
12	10	
Total	120	
%	÷ 120	

Question No. 1:

For a fully discrete whole life insurance of 10,000 on (50), you are given:

- $q_{59} = 0.020$ and $q_{60} = 0.030$
- $i = 0.05$
- Renewal expenses at the start of each year are 1 plus 1% of the gross premium.
- The gross premium reserve at duration 9 is 1475 and at duration 10 is 1587.

Calculate the annual gross premium.

Question No. 2:

An insurance company issues 750 fully discrete whole life insurance policies of $100,000 to individuals age 55 with independent future lifetimes. You are given:

- The following actual and expected experience in year 11:

Experience	actual	expected
Gross annual premium	$ 6000	$ 6000
Maintenance expenses per policy (payable b.o.y.)	425	300
Claim expenses per policy (payable at death)	125	200
q_{65}	0.06	0.04
Annual effective rate of interest	0.062	0.050

- Profits are calculated based on the following (per policy) gross premium reserve at the end of year 10:

$$_{10}V^g = 30,000$$

- At the end of the 10th year, 516 (of these) insurances remain in force.

Calculate the total gain or loss for the 11th year on this portfolio.

Question No. 3:

Hospital patients are classified as Sick (S), Critical (C), or Discharged (D). Transitions, in days, occur according to the following time-homogeneous transition probability matrix:

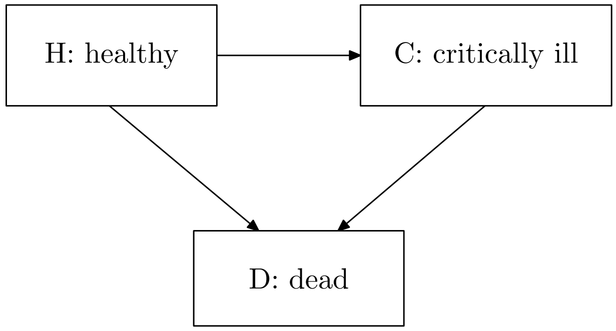
$$\begin{array}{c} \\ S \\ C \\ D \end{array} \begin{array}{c} \begin{array}{ccc} S & C & D \end{array} \\ \begin{pmatrix} 0.60 & 0.25 & 0.15 \\ 0.30 & 0.40 & 0.30 \\ 0.00 & 0.00 & 1.00 \end{pmatrix} \end{array}$$

Suppose today that there are exactly 10 sick patients in the hospital. The state of each patient is independent of the state of any other patient.

Calculate the probability that at least 3 of these 10 sick patients will be discharged by the end of two days from today.

Question No. 4:

A life insurer uses the following three-state model to price a two-year critical illness policy issued to healthy policyholders at time $t = 0$:



You are given:

- The constant forces of transition are:

$$\mu^{\text{HC}} = 0.010 \qquad \mu^{\text{HD}} = 0.001 \qquad \mu^{\text{CD}} = 0.025$$

- The policy pays 10,000 at the moment the policyholder becomes critically ill. No other benefits are provided.

- $\delta = 4\%$

Calculate the actuarial present value of the benefits for this critical illness policy.

Question No. 5:

In a triple decrement table, you are given that decrement (1) is death, decrement (2) is disability, and decrement (3) is withdrawal. You are given:

- $q_{65}^{\prime(1)} = 0.06$, $q_{65}^{\prime(2)} = 0.03$ and $q_{65}^{\prime(3)} = 0.15$.
- Withdrawals occur only at the end of the year.
- Mortality and disability are uniformly distributed over each year of age in the associated single decrement tables.

Calculate $q_{65}^{(1)}$.

Question No. 6:

Simon, who is exactly age 60 today, joins XYZ Insurance Company. His annual salary is 250,000 and will remain constant each year. For simplicity, assume that retirement takes place on a birthday.

XYZ offers a pension plan to Simon with the following benefits:

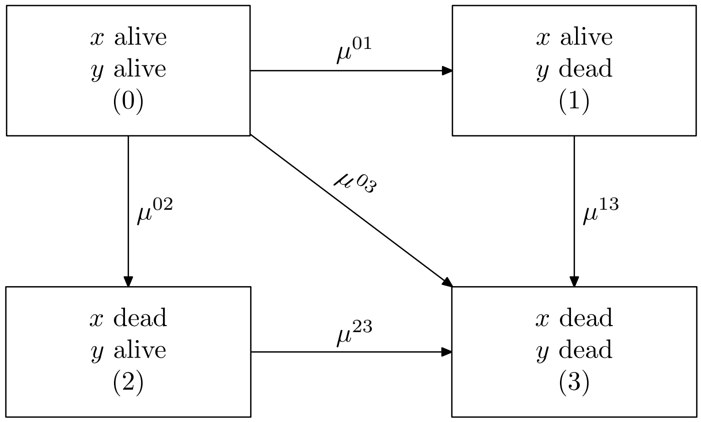
- a retirement benefit equal to 50,000 at time of retirement if he retires at age 63, or 75,000 at time of retirement if he retires at age 64, or 100,000 at time of retirement if he retires at age 65; and
- no other benefits are provided.

Decrements for this pension plan follow the *Standard Service Table* and $i = 0.05$.

Calculate the actuarial present value of his retirement benefits.

Question No. 7:

The joint mortality of two lines (x) and (y) is being modeled as a multiple state model with a common shock as depicted below:



You are given:

- $\mu^{01} = 0.015$
- $\mu^{02} = 0.025$
- $\delta = 0.035$

A special joint whole life insurance pays 10,000 at the moment of simultaneous death, if that occurs, and zero otherwise. The actuarial present value of this special insurance is 260.

Calculate μ^{03}.

Question No. 8:

For a whole life insurance policy that provides sickness benefit, you are given:

- The policy is issued to a `Healthy` person age 55.
- Premium is payable continuously at the annual rate of P so long as the policyholder is `Healthy`.
- A sickness benefit of 10,000 per year is payable while the policyholder is Sick.
- A benefit of 200,000 is payable at the moment of `Death` of the policyholder.
- $i = 0.05$
- All probabilities and actuarial functions are based on the *Standard Sickness-Death Model*.

Calculate P.

Question No. 9:

You are given the following information for Jeff, exact age 35, who just joined a defined benefit pension plan:

- The plan provides a retirement pension of 2% of final average salary for each year of service. The final average salary is defined as the average salary in the three years before retirement.
- His current salary is 65,000 and is expected to increase 4.0% annually on his birthdays.
- He will retire at exact age 65.

Calculate the replacement ratio provided by Jeff's pension plan.

Question No. 10:

A defined benefit pension plan provides participants, upon retirement at age 65, an annual pension equal to 1.5% of final salary per year of service. Final salary is defined to be the salary in the calendar year just prior to retirement. The pension benefit will be paid in the form of a life annuity payable for life at the beginning of each month. Funding method used is Traditional Unit Credit (TUC).

Death is the only decrement prior to retirement.

Sheila joined the pension plan at exact age 25 on January 1, 2003, with a then salary of 75,000. She expected this salary to increase by 4% each year on her birthday. As of January 1, 2018, her annual salary has always increased at that rate.

You are given: $i = 0.05$ $\quad {}_{25}p_{40} = 0.75$ $\quad \ddot{a}_{65}^{(12)} = 11.0$

Calculate actuarial liability of Sheila's retirement benefit on January 1, 2018.

Question No. 11:

Ree, age 30 on January 1, 2019, is a participant of a defined benefit pension plan. You are given:

- She was hired on January 1, 2014 with a salary of 50,000.
- She has received a salary increase of 5% each January 1; the employer expects to continue those increases until her retirement.
- The retirement benefit, payable annually at the start of the year, is 2% of 3-year final average salary times the number of years of service.
- Retirement occurs only at age 65.
- Other decrements, which are assumed to occur in the middle of the year, are 2% per year. No benefits are paid to those who leave before retirement.
- $i = 0.05$
- $\ddot{a}_{65} = 11$
- The pension plan uses the Projected Unit Credit (PUC) funding method.

Calculate the normal cost contribution for Ree for the year beginning January 1, 2019.

Question No. 12:

For two lives (50) and (60) with independent future lifetimes, you are given:

- ${}_{10}p_{50} = 0.95$
- ${}_{10}p_{\overline{50:60}} = 0.99$

Calculate ${}_{10}p_{50:60}$.

EXTRA PAGE FOR ADDITIONAL OR SCRATCH WORK

Standard Ultimate Life Table: Basic Functions and Single Net Premiums at i = 0.05

x	l_x	q_x	$\ddot{a}_x$	A_x	${}^2A_x$	$\ddot{a}_{x:\overline{10}\vert}$	$A_{x:\overline{10}\vert}$	$\ddot{a}_{x:\overline{20}\vert}$	$A_{x:\overline{20}\vert}$	${}_5E_x$	${}_{10}E_x$	${}_{20}E_x$	x
20	100,000.0	0.000250	19.9664	0.04922	0.00580	8.0991	0.61433	13.0559	0.37829	0.78252	0.61224	0.37440	20
21	99,975.0	0.000253	19.9197	0.05144	0.00614	8.0990	0.61433	13.0551	0.37833	0.78250	0.61220	0.37429	21
22	99,949.7	0.000257	19.8707	0.05378	0.00652	8.0988	0.61434	13.0541	0.37837	0.78248	0.61215	0.37417	22
23	99,924.0	0.000262	19.8193	0.05622	0.00694	8.0986	0.61435	13.0531	0.37842	0.78245	0.61210	0.37404	23
24	99,897.8	0.000267	19.7655	0.05879	0.00739	8.0983	0.61437	13.0519	0.37848	0.78243	0.61205	0.37390	24
25	99,871.1	0.000273	19.7090	0.06147	0.00788	8.0981	0.61438	13.0506	0.37854	0.78240	0.61198	0.37373	25
26	99,843.8	0.000280	19.6499	0.06429	0.00841	8.0978	0.61439	13.0491	0.37862	0.78236	0.61191	0.37354	26
27	99,815.9	0.000287	19.5878	0.06725	0.00900	8.0974	0.61441	13.0474	0.37869	0.78233	0.61183	0.37334	27
28	99,787.2	0.000296	19.5228	0.07034	0.00964	8.0970	0.61443	13.0455	0.37878	0.78229	0.61174	0.37310	28
29	99,757.7	0.000305	19.4547	0.07359	0.01033	8.0966	0.61445	13.0434	0.37888	0.78224	0.61163	0.37284	29
30	99,727.3	0.000315	19.3834	0.07698	0.01109	8.0961	0.61447	13.0410	0.37900	0.78219	0.61152	0.37254	30
31	99,695.8	0.000327	19.3086	0.08054	0.01192	8.0956	0.61450	13.0384	0.37913	0.78213	0.61139	0.37221	31
32	99,663.2	0.000341	19.2303	0.08427	0.01281	8.0949	0.61453	13.0354	0.37927	0.78206	0.61124	0.37183	32
33	99,629.3	0.000356	19.1484	0.08817	0.01379	8.0943	0.61456	13.0320	0.37943	0.78199	0.61108	0.37141	33
34	99,593.8	0.000372	19.0626	0.09226	0.01486	8.0935	0.61460	13.0282	0.37961	0.78190	0.61090	0.37094	34
35	99,556.7	0.000391	18.9728	0.09653	0.01601	8.0926	0.61464	13.0240	0.37981	0.78181	0.61069	0.37041	35
36	99,517.8	0.000412	18.8788	0.10101	0.01727	8.0916	0.61468	13.0192	0.38004	0.78170	0.61046	0.36982	36
37	99,476.7	0.000436	18.7805	0.10569	0.01863	8.0905	0.61474	13.0138	0.38029	0.78158	0.61020	0.36915	37
38	99,433.3	0.000463	18.6777	0.11059	0.02012	8.0893	0.61480	13.0078	0.38058	0.78145	0.60990	0.36841	38
39	99,387.3	0.000493	18.5701	0.11571	0.02173	8.0879	0.61486	13.0011	0.38090	0.78130	0.60957	0.36757	39
40	99,338.3	0.000527	18.4578	0.12106	0.02347	8.0863	0.61494	12.9935	0.38126	0.78113	0.60920	0.36663	40
41	99,285.9	0.000565	18.3403	0.12665	0.02536	8.0846	0.61502	12.9850	0.38167	0.78094	0.60879	0.36558	41
42	99,229.8	0.000608	18.2176	0.13249	0.02741	8.0826	0.61511	12.9754	0.38212	0.78072	0.60832	0.36440	42
43	99,169.4	0.000656	18.0895	0.13859	0.02963	8.0804	0.61522	12.9647	0.38263	0.78048	0.60780	0.36307	43
44	99,104.3	0.000710	17.9558	0.14496	0.03203	8.0779	0.61534	12.9526	0.38321	0.78021	0.60721	0.36159	44
45	99,033.9	0.000771	17.8162	0.15161	0.03463	8.0751	0.61547	12.9391	0.38385	0.77991	0.60655	0.35994	45
46	98,957.6	0.000839	17.6706	0.15854	0.03744	8.0720	0.61562	12.9240	0.38457	0.77956	0.60581	0.35809	46
47	98,874.5	0.000916	17.5189	0.16577	0.04047	8.0684	0.61579	12.9070	0.38538	0.77918	0.60498	0.35601	47
48	98,783.9	0.001003	17.3607	0.17330	0.04374	8.0645	0.61598	12.8880	0.38629	0.77875	0.60404	0.35370	48
49	98,684.9	0.001100	17.1960	0.18114	0.04727	8.0600	0.61619	12.8667	0.38730	0.77827	0.60299	0.35112	49
50	98,576.4	0.001209	17.0245	0.18931	0.05108	8.0550	0.61643	12.8428	0.38844	0.77772	0.60182	0.34824	50
51	98,457.2	0.001331	16.8461	0.19780	0.05517	8.0494	0.61670	12.8161	0.38971	0.77711	0.60050	0.34503	51
52	98,326.2	0.001469	16.6606	0.20664	0.05957	8.0431	0.61700	12.7862	0.39113	0.77643	0.59902	0.34146	52
53	98,181.8	0.001623	16.4678	0.21582	0.06430	8.0360	0.61733	12.7527	0.39273	0.77566	0.59736	0.33749	53
54	98,022.4	0.001797	16.2676	0.22535	0.06938	8.0281	0.61771	12.7154	0.39451	0.77479	0.59550	0.33308	54
55	97,846.2	0.001993	16.0599	0.23524	0.07483	8.0192	0.61813	12.6737	0.39649	0.77382	0.59342	0.32819	55
56	97,651.2	0.002212	15.8444	0.24550	0.08067	8.0092	0.61861	12.6271	0.39871	0.77273	0.59109	0.32279	56
57	97,435.2	0.002459	15.6212	0.25613	0.08692	7.9980	0.61914	12.5752	0.40118	0.77151	0.58848	0.31681	57
58	97,195.6	0.002736	15.3901	0.26714	0.09360	7.9854	0.61974	12.5174	0.40393	0.77014	0.58556	0.31024	58
59	96,929.6	0.003048	15.1511	0.27852	0.10073	7.9713	0.62041	12.4531	0.40700	0.76860	0.58229	0.30300	59
60	96,634.1	0.003398	14.9041	0.29028	0.10834	7.9555	0.62116	12.3816	0.41040	0.76687	0.57864	0.29508	60

Standard Ultimate Life Table: Basic Functions and Single Net Premiums at *i* = 0.05

x	l_x	q_x	$\ddot{a}_x$	A_x	${}^2A_x$	$\ddot{a}_{x:\overline{10}\rvert}$	$A_{x:\overline{10}\rvert}$	$\ddot{a}_{x:\overline{20}\rvert}$	$A_{x:\overline{20}\rvert}$	${}_5E_x$	${}_{10}E_x$	${}_{20}E_x$	x
61	96,305.8	0.003792	14.6491	0.30243	0.11644	7.9379	0.62201	12.3024	0.41417	0.76493	0.57457	0.28641	61
62	95,940.6	0.004234	14.3861	0.31495	0.12506	7.9181	0.62295	12.2145	0.41836	0.76276	0.57003	0.27698	62
63	95,534.4	0.004730	14.1151	0.32785	0.13421	7.8960	0.62400	12.1174	0.42298	0.76033	0.56496	0.26674	63
64	95,082.5	0.005288	13.8363	0.34113	0.14392	7.8712	0.62518	12.0101	0.42809	0.75760	0.55932	0.25569	64
65	94,579.7	0.005915	13.5498	0.35477	0.15420	7.8435	0.62650	11.8920	0.43371	0.75455	0.55305	0.24381	65
66	94,020.3	0.006619	13.2557	0.36878	0.16507	7.8126	0.62797	11.7622	0.43990	0.75114	0.54609	0.23112	66
67	93,398.1	0.007409	12.9542	0.38313	0.17654	7.7781	0.62961	11.6199	0.44667	0.74732	0.53836	0.21764	67
68	92,706.1	0.008297	12.6456	0.39783	0.18862	7.7396	0.63145	11.4643	0.45408	0.74305	0.52981	0.20343	68
69	91,936.9	0.009294	12.3302	0.41285	0.20133	7.6968	0.63349	11.2949	0.46215	0.73828	0.52036	0.18856	69
70	91,082.4	0.010413	12.0083	0.42818	0.21467	7.6491	0.63576	11.1109	0.47091	0.73295	0.50994	0.17313	70
71	90,134.0	0.011670	11.6803	0.44379	0.22864	7.5961	0.63828	10.9118	0.48039	0.72701	0.49848	0.15730	71
72	89,082.1	0.013081	11.3468	0.45968	0.24324	7.5373	0.64108	10.6974	0.49060	0.72039	0.48590	0.14122	72
73	87,916.8	0.014664	11.0081	0.47580	0.25847	7.4721	0.64419	10.4675	0.50155	0.71303	0.47215	0.12511	73
74	86,627.6	0.016440	10.6649	0.49215	0.27433	7.3999	0.64762	10.2221	0.51323	0.70483	0.45715	0.10918	74
75	85,203.5	0.018433	10.3178	0.50868	0.29079	7.3203	0.65142	9.9616	0.52564	0.69574	0.44085	0.09368	75
76	83,632.9	0.020668	9.9674	0.52536	0.30783	7.2325	0.65560	9.6866	0.53873	0.68566	0.42323	0.07887	76
77	81,904.3	0.023175	9.6145	0.54217	0.32544	7.1360	0.66019	9.3980	0.55247	0.67450	0.40427	0.06500	77
78	80,006.2	0.025984	9.2598	0.55906	0.34359	7.0302	0.66523	9.0970	0.56681	0.66217	0.38396	0.05230	78
79	77,927.4	0.029132	8.9042	0.57599	0.36224	6.9146	0.67074	8.7850	0.58166	0.64859	0.36235	0.04096	79
80	75,657.2	0.032658	8.5484	0.59293	0.38134	6.7885	0.67674	8.4639	0.59696	0.63365	0.33952	0.03113	80
81	73,186.3	0.036607	8.1934	0.60984	0.40086	6.6517	0.68325	8.1354	0.61260	0.61727	0.31556	0.02286	81
82	70,507.2	0.041025	7.8401	0.62666	0.42075	6.5037	0.69030	7.8018	0.62848	0.59936	0.29064	0.01616	82
83	67,614.6	0.045968	7.4893	0.64336	0.44094	6.3443	0.69789	7.4651	0.64452	0.57985	0.26498	0.01094	83
84	64,506.5	0.051493	7.1421	0.65990	0.46137	6.1735	0.70602	7.1275	0.66059	0.55868	0.23882	0.00706	84
85	61,184.9	0.057665	6.7993	0.67622	0.48199	5.9915	0.71469	6.7910	0.67662	0.53581	0.21250	0.00431	85
86	57,656.7	0.064554	6.4619	0.69229	0.50272	5.7986	0.72388	6.4574	0.69250	0.51122	0.18635	0.00248	86
87	53,934.7	0.072237	6.1308	0.70806	0.52349	5.5954	0.73355	6.1285	0.70817	0.48492	0.16079	0.00133	87
88	50,038.6	0.080798	5.8068	0.72349	0.54422	5.3828	0.74368	5.8057	0.72354	0.45697	0.13621	0.00066	88
89	45,995.6	0.090326	5.4908	0.73853	0.56484	5.1620	0.75419	5.4903	0.73856	0.42748	0.11305	0.00030	89
90	41,841.1	0.100917	5.1835	0.75317	0.58528	4.9346	0.76502	5.1833	0.75317	0.39659	0.09168	0.00012	90
91	37,618.6	0.112675	4.8858	0.76735	0.60545	4.7021	0.77609	4.8857	0.76735	0.36453	0.07244	0.00005	91
92	33,379.9	0.125708	4.5981	0.78104	0.62529	4.4665	0.78731	4.5981	0.78104	0.33158	0.05559	0.00002	92
93	29,183.8	0.140128	4.3213	0.79423	0.64472	4.2299	0.79858	4.3213	0.79423	0.29808	0.04128	0.00000	93
94	25,094.3	0.156052	4.0556	0.80688	0.66368	3.9945	0.80979	4.0556	0.80688	0.26445	0.02955	0.00000	94
95	21,178.3	0.173599	3.8017	0.81897	0.68209	3.7624	0.82084	3.8017	0.81897	0.23116	0.02029	0.00000	95
96	17,501.8	0.192887	3.5597	0.83049	0.69991	3.5356	0.83164	3.5597	0.83049	0.19872	0.01330	0.00000	96
97	14,125.9	0.214030	3.3300	0.84143	0.71708	3.3159	0.84210	3.3300	0.84143	0.16765	0.00827	0.00000	97
98	11,102.5	0.237134	3.1127	0.85177	0.73356	3.1050	0.85214	3.1127	0.85177	0.13850	0.00485	0.00000	98
99	8,469.7	0.262294	2.9079	0.86153	0.74930	2.9039	0.86172	2.9079	0.86153	0.11173	0.00266	0.00000	99
100	6,248.2	0.289584	2.7156	0.87068	0.76427	2.7137	0.87078	2.7156	0.87068	0.08777	0.00136	0.00000	100

Standard Ultimate Life Table: Basic Functions and Single Net Premiums at i = 0.05

Lives are Independent.

x	$\ddot{a}_{xx}$	A_{xx}	${}^2A_{xx}$	$\ddot{a}_{x:x:\overline{10}\rvert}$	$\ddot{a}_{x:x+10}$	$A_{x:x+10}$	${}^2A_{x:x+10}$	$\ddot{a}_{x:x+10:\overline{10}\rvert}$	x
30	18.8224	0.10369	0.01917	8.0844	18.1212	0.13709	0.03001	8.0747	30
31	18.7253	0.10832	0.02052	8.0833	17.9924	0.14322	0.03227	8.0724	31
32	18.6238	0.11315	0.02198	8.0821	17.8579	0.14962	0.03472	8.0698	32
33	18.5176	0.11821	0.02357	8.0807	17.7176	0.15630	0.03736	8.0669	33
34	18.4066	0.12350	0.02529	8.0792	17.5713	0.16327	0.04022	8.0636	34
35	18.2905	0.12902	0.02716	8.0774	17.4187	0.17054	0.04331	8.0600	35
36	18.1693	0.13480	0.02919	8.0755	17.2597	0.17811	0.04664	8.0559	36
37	18.0426	0.14083	0.03138	8.0733	17.0941	0.18600	0.05023	8.0513	37
38	17.9104	0.14713	0.03375	8.0708	16.9217	0.19421	0.05410	8.0461	38
39	17.7723	0.15370	0.03632	8.0680	16.7423	0.20275	0.05827	8.0403	39
40	17.6283	0.16055	0.03909	8.0649	16.5558	0.21163	0.06275	8.0337	40
41	17.4782	0.16771	0.04209	8.0614	16.3619	0.22086	0.06756	8.0264	41
42	17.3217	0.17516	0.04533	8.0575	16.1607	0.23044	0.07273	8.0182	42
43	17.1586	0.18292	0.04882	8.0531	15.9518	0.24039	0.07827	8.0090	43
44	16.9888	0.19101	0.05258	8.0481	15.7353	0.25070	0.08420	7.9986	44
45	16.8122	0.19942	0.05663	8.0426	15.5109	0.26139	0.09056	7.9870	45
46	16.6284	0.20817	0.06098	8.0363	15.2787	0.27244	0.09734	7.9740	46
47	16.4374	0.21727	0.06567	8.0293	15.0385	0.28388	0.10459	7.9594	47
48	16.2390	0.22671	0.07070	8.0215	14.7903	0.29570	0.11232	7.9431	48
49	16.0331	0.23652	0.07609	8.0126	14.5341	0.30790	0.12054	7.9248	49
50	15.8195	0.24669	0.08187	8.0027	14.2699	0.32048	0.12929	7.9044	50
51	15.5982	0.25723	0.08806	7.9916	13.9979	0.33344	0.13858	7.8815	51
52	15.3690	0.26814	0.09468	7.9792	13.7180	0.34676	0.14842	7.8559	52
53	15.1318	0.27944	0.10175	7.9653	13.4304	0.36046	0.15885	7.8272	53
54	14.8867	0.29111	0.10929	7.9496	13.1352	0.37451	0.16986	7.7953	54
55	14.6336	0.30316	0.11732	7.9321	12.8328	0.38891	0.18148	7.7596	55
56	14.3725	0.31559	0.12586	7.9125	12.5233	0.40365	0.19372	7.7199	56
57	14.1035	0.32840	0.13494	7.8906	12.2071	0.41871	0.20658	7.6756	57
58	13.8266	0.34159	0.14457	7.8660	11.8845	0.43407	0.22007	7.6264	58
59	13.5419	0.35515	0.15477	7.8386	11.5560	0.44972	0.23419	7.5717	59
60	13.2497	0.36906	0.16555	7.8080	11.2220	0.46562	0.24895	7.5110	60
61	12.9500	0.38333	0.17694	7.7738	10.8830	0.48176	0.26433	7.4438	61
62	12.6432	0.39794	0.18893	7.7357	10.5396	0.49811	0.28033	7.3694	62
63	12.3296	0.41288	0.20155	7.6932	10.1925	0.51464	0.29693	7.2874	63
64	12.0094	0.42812	0.21480	7.6459	9.8423	0.53132	0.31411	7.1971	64
65	11.6831	0.44366	0.22868	7.5934	9.4898	0.54810	0.33185	7.0978	65
66	11.3511	0.45947	0.24320	7.5351	9.1358	0.56496	0.35011	6.9892	66
67	11.0140	0.47552	0.25834	7.4704	8.7810	0.58186	0.36886	6.8704	67
68	10.6722	0.49180	0.27410	7.3989	8.4263	0.59875	0.38806	6.7412	68
69	10.3265	0.50826	0.29047	7.3199	8.0726	0.61559	0.40766	6.6011	69
70	9.9774	0.52488	0.30743	7.2329	7.7208	0.63234	0.42760	6.4497	70
71	9.6257	0.54163	0.32496	7.1371	7.3718	0.64896	0.44783	6.2870	71
72	9.2722	0.55847	0.34302	7.0321	7.0267	0.66540	0.46830	6.1129	72
73	8.9175	0.57536	0.36159	6.9173	6.6862	0.68161	0.48892	5.9276	73
74	8.5627	0.59225	0.38062	6.7922	6.3513	0.69756	0.50963	5.7316	74
75	8.2085	0.60912	0.40007	6.6563	6.0229	0.71320	0.53036	5.5256	75
76	7.8559	0.62591	0.41989	6.5093	5.7019	0.72848	0.55103	5.3106	76
77	7.5057	0.64258	0.44002	6.3510	5.3891	0.74338	0.57158	5.0878	77
78	7.1590	0.65910	0.46040	6.1812	5.0852	0.75785	0.59191	4.8588	78
79	6.8166	0.67540	0.48097	6.0002	4.7910	0.77186	0.61196	4.6254	79
80	6.4794	0.69146	0.50165	5.8083	4.5071	0.78538	0.63165	4.3896	80

Standard Sickness-Death Model

Functions at $i = 0.05$

Healthy (State 0) can transition to Sick (State 1) or Death (State 2)

Sick (State 1) can transition to Healthy (State 0) or Death (State 2)

Death (State 2) cannot transition

x	$\bar{a}_x^{00}$	$\bar{a}_x^{01}$	$\bar{a}_x^{11}$	$\bar{a}_x^{10}$	$\bar{A}_x^{01}$	$\bar{A}_x^{02}$	$\bar{A}_x^{10}$	$\bar{A}_x^{12}$	${}_{10}p_x^{00}$	${}_{10}p_x^{01}$	${}_{10}p_x^{11}$	${}_{10}p_x^{10}$
50	11.7454	1.9621	12.3919	0.6675	0.24144	0.33126	0.06550	0.36288	0.83936	0.06554	0.81210	0.06063
51	11.4326	2.0306	12.2393	0.5626	0.25196	0.34318	0.05702	0.37544	0.82316	0.07379	0.81016	0.05215
52	11.1135	2.0994	12.0672	0.4731	0.26284	0.35539	0.04958	0.38820	0.80533	0.08298	0.80636	0.04473
53	10.7886	2.1684	11.8777	0.3969	0.27410	0.36787	0.04307	0.40116	0.78577	0.09318	0.80078	0.03827
54	10.4582	2.2373	11.6727	0.3321	0.28574	0.38063	0.03737	0.41432	0.76433	0.10444	0.79346	0.03264
55	10.1228	2.3057	11.4542	0.2772	0.29774	0.39366	0.03240	0.42766	0.74091	0.11682	0.78447	0.02774
56	9.7829	2.3734	11.2236	0.2309	0.31011	0.40694	0.02806	0.44117	0.71540	0.13035	0.77383	0.02350
57	9.4391	2.4400	10.9825	0.1918	0.32284	0.42046	0.02428	0.45484	0.68772	0.14506	0.76160	0.01983
58	9.0920	2.5052	10.7321	0.1589	0.33593	0.43421	0.02099	0.46866	0.65779	0.16093	0.74778	0.01666
59	8.7424	2.5685	10.4737	0.1313	0.34936	0.44819	0.01813	0.48260	0.62559	0.17790	0.73241	0.01392
60	8.3908	2.6295	10.2084	0.1082	0.36312	0.46236	0.01565	0.49667	0.59115	0.19589	0.71551	0.01158
61	8.0382	2.6878	9.9372	0.0890	0.37719	0.47671	0.01349	0.51083	0.55452	0.21472	0.69708	0.00957
62	7.6853	2.7430	9.6612	0.0729	0.39156	0.49124	0.01162	0.52508	0.51586	0.23419	0.67717	0.00786
63	7.3330	2.7945	9.3811	0.0596	0.40621	0.50590	0.01000	0.53939	0.47539	0.25397	0.65579	0.00641
64	6.9822	2.8421	9.0979	0.0486	0.42111	0.52070	0.00860	0.55373	0.43342	0.27370	0.63297	0.00518
65	6.6338	2.8851	8.8123	0.0395	0.43624	0.53559	0.00738	0.56810	0.39038	0.29288	0.60878	0.00415
66	6.2888	2.9231	8.5251	0.0320	0.45157	0.55056	0.00633	0.58247	0.34677	0.31096	0.58326	0.00329
67	5.9480	2.9558	8.2370	0.0259	0.46706	0.56559	0.00543	0.59681	0.30322	0.32730	0.55649	0.00257
68	5.6125	2.9827	7.9488	0.0208	0.48269	0.58064	0.00465	0.61111	0.26043	0.34119	0.52856	0.00199
69	5.2832	3.0034	7.6610	0.0167	0.49843	0.59568	0.00397	0.62534	0.21916	0.35193	0.49958	0.00152
70	4.9609	3.0177	7.3744	0.0134	0.51423	0.61070	0.00339	0.63947	0.18020	0.35881	0.46970	0.00114
71	4.6466	3.0252	7.0894	0.0107	0.53005	0.62566	0.00290	0.65349	0.14429	0.36123	0.43907	0.00084
72	4.3412	3.0257	6.8069	0.0085	0.54587	0.64052	0.00247	0.66736	0.11210	0.35871	0.40787	0.00061
73	4.0453	3.0190	6.5272	0.0067	0.56162	0.65527	0.00210	0.68107	0.08415	0.35101	0.37631	0.00043
74	3.7596	3.0051	6.2509	0.0053	0.57729	0.66987	0.00179	0.69459	0.06074	0.33813	0.34463	0.00030
75	3.4849	2.9838	5.9786	0.0042	0.59283	0.68430	0.00152	0.70791	0.04192	0.32040	0.31308	0.00020
76	3.2217	2.9552	5.7107	0.0033	0.60819	0.69851	0.00128	0.72099	0.02749	0.29844	0.28193	0.00013
77	2.9704	2.9195	5.4478	0.0025	0.62334	0.71249	0.00109	0.73382	0.01701	0.27312	0.25145	0.00009
78	2.7315	2.8769	5.1902	0.0020	0.63824	0.72621	0.00092	0.74638	0.00985	0.24552	0.22193	0.00005
79	2.5050	2.8275	4.9383	0.0015	0.65285	0.73964	0.00078	0.75865	0.00528	0.21679	0.19366	0.00003

Standard Service Table

x	l_x	w_x	i_x	r_x	d_x	x	l_x	w_x	i_x	r_x	d_x	
35	218,833.9	10,665.3	213.3	0	83.5	51	114,572.5	2,266.1	113.3	0	150.9	
36	207,871.8	10,130.9	202.6	0	83.6	52	112,042.2	2,215.9	110.8	0	162.8	
37	197,454.7	9,623.1	192.5	0	84.0	53	109,552.7	2,166.5	108.3	0	176.0	
38	187,555.1	9,140.6	182.8	0	84.7	54	107,101.9	2,117.8	105.9	0	190.5	
39	178,147.0	8,681.9	173.6	0	85.7	55	104,687.7	2,069.9	103.5	0	206.4	
40	169,205.8	8,246.0	164.9	0	86.9	56	102,307.9	2,022.6	101.1	0	223.9	
41	160,707.9	7,831.8	156.6	0	88.5	57	99,960.2	1,976.0	98.8	0	243.2	
42	152,631.0	7,438.0	148.8	0	90.5	58	97,642.2	1,929.9	96.5	0	264.4	
43	144,953.7	7,063.7	141.3	0	92.7	59	95,351.5	1,884.3	94.2	0	287.6	
44	137,656.1	6,707.9	134.2	0	95.3	60	93,085.4	0	0	27,925.6	0	Exact Age
45	130,718.7	2,586.1	129.3	0	99.7	60	65,159.8	0	61.9	6,187.6	210.4	
46	127,903.5	2,530.4	126.5	0	106.2	61	58,699.9	0	55.7	5,573.1	211.5	
47	125,140.4	2,475.6	123.8	0	113.4	62	52,859.6	0	50.2	5,017.5	212.7	
48	122,427.6	2,421.8	121.1	0	121.4	63	47,579.3	0	45.2	4,515.2	213.9	
49	119,763.2	2,369.0	118.5	0	130.3	64	42,805.0	0	40.6	4,061.0	215.1	
50	117,145.5	2,317.1	115.9	0	140.1	65	38,488.3	0	0	38,488.3	0	Exact Age

$w_x \rightarrow$ withdrawals; $i_x \rightarrow$ disability; $r_x \rightarrow$ retirements; $d_x \rightarrow$ deaths