Questions 3 and 4: insurance rates, part 2

Life insurance rates are calculated using mortality statistics from the recent past. They are priced such that companies are almost assured to profit as long as the probability of death remains similar. If an event occurs that changes the probability of death in a given age group, the company risks significant losses.

In this 6-part question, we'll look at a scenario in which a lethal pandemic disease increases the probability of death within 1 year for a 50 year old to .015. Unable to predict the outbreak, the company has sold 1,000 $150,000 life insurance policies for $1,150.

Question 3a

1.0/1.0 point (graded)

What is the expected value of the company's profits over 1,000 policies?

-1117250

✔ **Answer:** -1117250

-1117250

Explanation

The expected value can be calculated using the following code:

```
p <- .015    # probability of claim
a <- -150000    # loss per claim
b <- 1150    # premium - profit when no claim
n <- 1000

exp_val <- n*(a*p + b*(1-p))
exp_val
```

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You have used 1 of 10 attempts

Answers are displayed within the problem

Question 3b

1.0/1.0 point (graded)
What is the standard error of the expected value of the company's profits over 1,000 policies?

580994 ✔ **Answer:** 580994

580994

Explanation
The standard error can be calculated using the following code:

```
se <- sqrt(n) * abs(b-a) * sqrt(p*(1-p))
se
```

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Question 3c

1.0/1.0 point (graded)
What is the probability of the company losing money?

0.973 ✔ **Answer:** 0.973

0.973

Explanation
The probability can be calculated using the following code:

```
pnorm(0, exp_val, se)
```

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Question 3d

1.0/1.0 point (graded)
Suppose the company can afford to sustain one-time losses of $1 million, but larger losses will force it to go out of business.

What is the probability of losing more than $1 million?

0.58 ✔ **Answer:** 0.58

0.58

Explanation
The probability can be calculated using the following code:

```
pnorm(-1*10^6, exp_val, se)
```

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Question 3e

1.0/1.0 point (graded)
Investigate death probabilities `p <- seq(.01, .03, .0025)`.

What is the lowest death probability for which the chance of losing money exceeds 90%?

0.0125 ✔ **Answer:** 0.013

0.0125

Explanation
The probability can be calculated using the following code:

```
p <- seq(.01, .03, .001)
a <- -150000    # loss per claim
b <- 1150    # premium - profit when no claim
n <- 1000

p_lose_money <- sapply(p, function(p){
  exp_val <- n*(a*p + b*(1-p))
  se <- sqrt(n) * abs(b-a) * sqrt(p*(1-p))
  pnorm(0, exp_val, se)
})

data.frame(p, p_lose_money) %>%
  filter(p_lose_money > 0.9) %>%
  pull(p) %>%
  min()
```

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Question 3f

1.0/1.0 point (graded)
Investigate death probabilities `p <- seq(.01, .03, .0025)`.

What is the lowest death probability for which the chance of losing over $1 million exceeds 90%?

0.0200 ✔ **Answer:** 0.02

0.0200

Explanation
The probability can be calculated using the following code:

```
p_lose_million <- sapply(p, function(p){
  exp_val <- n*(a*p + b*(1-p))
  se <- sqrt(n) * abs(b-a) * sqrt(p*(1-p))
  pnorm(-1*10^6, exp_val, se)
})

data.frame(p, p_lose_million) %>%
  filter(p_lose_million > 0.9) %>%
  pull(p) %>%
  min()
```

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Answers are displayed within the problem

Question 4, which has two parts, continues the scenario from Question 3.

Question 4a

1.0/1.0 point (graded)
Define a sampling model for simulating the total profit over 1,000 loans with probability of claim `p_loss = .015`, loss of -$150,000 on a claim, and profit of $1,150 when there is no claim. Set the seed to 25, then run the model once.

(IMPORTANT! If you use R 3.6 or later, you will need to use the command `set.seed(x, sample.kind = "Rounding")` instead of `set.seed(x)`. Your R version will be printed at the top of the Console window when you start RStudio.)

What is the reported profit (or loss) in millions?

-1.41 ✔ **Answer:** -1.42

-1.41

Explanation
The reported loss can be calculated using the following code:

```
set.seed(25)

p <- .015
loss <- -150000
profit <- 1150
n <- 1000

outcomes <- sample(c(loss, profit), n, prob = c(p, 1-p), replace = TRUE)
sum(outcomes)/10^6
```

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Answers are displayed within the problem

Question 4b

1.0/1.0 point (graded)
Set the seed to 27, then run a Monte Carlo simulation of your sampling model with 10,000 replicates to simulate the range of profits/losses over 1,000 loans.

(IMPORTANT! If you use R 3.6 or later, you will need to use the command `set.seed(x, sample.kind = "Rounding")` instead of `set.seed(x)`. Your R version will be printed at the top of the Console window when you start RStudio.)

What is the observed probability of losing $1 million or more?

0.539 ✔ **Answer:** 0.539

0.539

Explanation
The probability can be calculated using the following code:

```
set.seed(27)
B <- 10000

profits <- replicate(B, {
  outcomes <- sample(c(loss, profit), n, prob = c(p, 1-p), replace = TRUE)
  sum(outcomes)/10^6
})

mean(profits < -1)
```

Submit

You have used 2 of 10 attempts

Answers are displayed within the problem