1.

In the supplemental material, you have been given a case study, “Systolic Blood Pressure Case Study”, showing the results of different treatment options and the description of how that study was set up. There are different ways of setting up models to examine the benefits of the different treatment options. You have been asked which of two model structures will give a better fit to the experience.

Model Structure XYZ has:

- All eight treatment options in the fixed effects section of the model
- A random effect of doctors nested within hospitals
- An assumption that the variance that variance by treatment can be grouped under Variance Group #1

Model Structure STW has:

- All eight treatment options in the fixed effects section of the model
- A random effect of doctors nested within hospitals
- An assumption that the variance by treatment can be grouped under Variance Group #2

The null hypothesis is that variance is constant across all treatment effects.

Determine the level of significance at which one would reject the null hypothesis using a likelihood ratio test.

A. Less than .005
B. At least .005, but less than .01
C. At least .01, but less than .025
D. At least .025, but less than .05
E. Greater than .05

2.

In the supplemental material, you have been given a case study, “Systolic Blood Pressure Case Study”, showing the results of different treatment options and the description of how that study was set up. There are different ways of setting up models to examine the benefits of the different treatment options. You have been asked which of two models structures will give a better fit to the experience.

Model Structure XYZ has:

- Treatment options should be grouped using Mean Group #1 in the fixed effects section of the model
- A random effect of doctors nested within hospitals
- An assumption that the variance that variance by treatment can be grouped under Variance Group #1

Model Structure STW has:

- All eight treatment options in the fixed effects section of the model
- A random effect of doctors nested within hospitals
- An assumption that the variance that variance by treatment can be grouped under Variance Group #1

The null hypothesis is that the Mean Group #1 should be retained to evaluate the effectiveness of treatment options.

Determine the level of significance at which one would reject the null hypothesis using a likelihood ratio test.

A. Less than .005
B. At least .005, but less than .01
C. At least .01, but less than .025
D. At least .025, but less than .05
E. Greater than .05

3.

You are given:

- Claim frequency each month follows a Poisson distribution with mean λ.
- λ follows a gamma distribution with $\alpha = 8$ and $\theta = 0.02$.
- The following table of claim experience for a company:

Month	Number of Insureds	Number of Claims
1	50	4
2	100	10
3	150	11
4	200	---

Calculate the estimated claim count for Month 4 using the Bühlmann-Straub credibility approach.

A. Fewer than 12
B. At least 12, but fewer than 15
C. At least 15, but fewer than 18
D. At least 18, but fewer than 21
E. At least 21

4.

You are given:

- X is the claim severity random variable which can take values 100, 250, or 500.
- The distribution of X differs by the risk group, θ.
- The following data table:

			$P[X = x\|\theta]$		
θ	$P[\Theta = \theta]$	Claim Frequency	$x = 100$	$x = 250$	$x = 500$
1	0.30	0.25	0.20	0.20	0.60
2	0.30	0.50	0.50	0.50	0.00
3	0.40	0.25	0.50	0.25	0.25

A sample of three claims with claim severities of 250, 250, and 500 is observed.

Calculate the posterior mean of X.

A. Less than 300
B. At least 300, but less than 320
C. At least 320, but less than 340
D. At least 340, but less than 360
E. At least 360

5.

You are considering two models

Reference Model

$$Y_{ij} = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1 \boldsymbol{X}_j^{(1)} + \boldsymbol{\beta}_2 \boldsymbol{X}_j^{(2)} + \boldsymbol{\beta}_3 \boldsymbol{X}_j^{(3)} + u_j + \varepsilon_{ij}$$

P equals -2 times the log-likelihood using the Maximum Likelihood (ML) estimates of these parameters.
Q equals -2 times the log-likelihood using the Restricted Maximum Likelihood (REML) estimates of these parameters.

Nested Model

$$Y_{ij} = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1 \boldsymbol{X}_j^{(1)} + \boldsymbol{\beta}_2 \boldsymbol{X}_j^{(2)} + u_j + \varepsilon_{ij}$$

R equals -2 times the log-likelihood using the ML estimates of these parameters.
S equals -2 times the log-likelihood using the REML estimates of these parameters.

You wish to use a likelihood ratio to test the null hypothesis of $\boldsymbol{\beta}_3 = 0$ against the alternative hypothesis of $\boldsymbol{\beta}_3 \neq 0$.

Determine the value of the test statistic for this likelihood ratio test.

A. Test Statistic = S / Q
B. Test Statistic = R / P
C. Test Statistic = S - Q
D. Test Statistic = R - P
E. None of (A), (B), (C) or (D)

6.

You have fit a Linear Mixed Model to a dataset consisting of severities for every claim observed in a certain time period, producing the following summary:

```
Linear mixed model fit by REML ['lmerMod']
Formula: Severity ~ Age + (1 | State)
   Data: SeverityAgeStateData

REML criterion at convergence: 2347.6

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.9602 -0.6086 -0.1042  0.5144  5.2686

Random effects:
 Groups   Name        Variance Std.Dev.
 State    (Intercept) 1.562    1.250
 Residual             2.920    1.709
Number of obs: 578, groups:  State, 50

Fixed effects:
                   Estimate Std. Error t value
(Intercept)        27.57033    1.81801  15.165
Age                -0.53549    0.06349  -8.434
```

The entry in the dataset for the single observed claim in Alaska is:

State	Age	Severity
Alaska	28.35	15.36

Calculate the empirical best linear unbiased predictor for the Alaska random effect.

A. Less than 1.2
B. At least 1.2 but less than 1.7
C. At least 1.7 but less than 2.2
D. At least 2.2 but less than 2.7
E. Greater than or equal to 2.7

7.

You are given the following statements about iterative numerical optimization algorithms to estimate the covariance parameters of a Linear Mixed Model.

I. The expectation-maximization algorithm tends to overestimate the covariance of the parameters.
II. The Newton-Raphson algorithm usually requires more iterations to converge than the expectation-maximization algorithm.
III. The Fisher scoring algorithm uses more simplified calculations than the Newton-Raphson algorithm and is not recommended to obtain final estimates.

Determine which of the preceding statements are true.

A. None of I, II, or III are true
B. I and II only
C. I and III only
D. II and III only
E. The answer is not given by (A), (B), (C), or (D)

8.

A stochastic process has the following relationship between a dependent random variable, Y, and independent random variables, X_1 and X_2:

$$y_i = 2.2 - 0.52x_{1i} + 0.465x_{2i} + \epsilon_i$$

Some data from the process was collected and split into a training and testing portion. An analysis was performed that involved fitting a series of models to the training portion of the data to uncover the relationship above. Each model has a different linear equation.

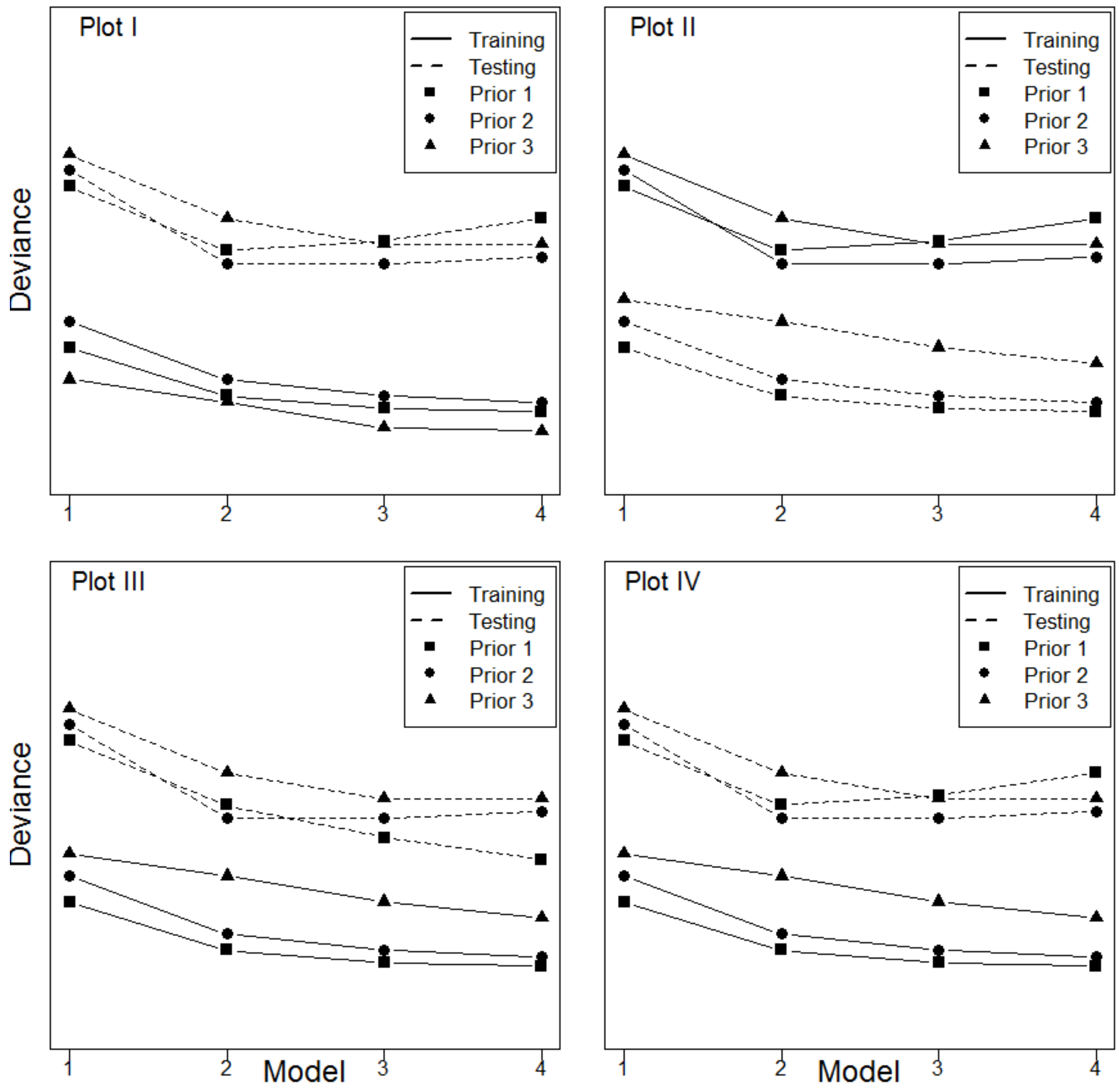
The four different models are given below.

$$\begin{aligned}
Model1:\ y_i &= \alpha + \beta_1 x_{1i} + \epsilon_i \\
Model2:\ y_i &= \alpha + \beta_1 x_{1i} + \beta_2 x_{2i} + \epsilon_i \\
Model3:\ y_i &= \alpha + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{1i}^2 + \epsilon_i \\
Model4:\ y_i &= \alpha + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{1i}^2 + \beta_4 x_{2i}^2 + \epsilon_i
\end{aligned}$$

Three sets of prior distributions on the β parameters are provided below. For a given model, all β parameters have the same prior distribution and α has the same prior distribution across all four models.

$$\begin{aligned}
Prior1:\ \beta_i &\sim Normal(0,\ 3.0);\ \ i = 1,2,3,4 \\
Prior2:\ \beta_i &\sim Normal(0,\ 0.5);\ \ i = 1,2,3,4 \\
Prior3:\ \beta_i &\sim Normal(0,\ 0.1);\ \ i = 1,2,3,4
\end{aligned}$$

Four plots that show deviance on training and testing data for each combination of model and prior distribution are presented on the following page. At most, only one of the plots was produced by the analysis. The observations in the training and testing data are the same for every model fit.



Determine which plot was most likely produced by this analysis.

A. Plot I
B. Plot II
C. Plot III
D. Plot IV
E. None of the plots

9.

Assume a mean μ for an unspecified distribution.

Consider the following statements.

I. If the actuary has strong prior beliefs about μ, it will affect the Bayesian's posterior estimate of μ.

II. In Bayesian inference, the probability that $\mu > 1000$ falls in [0, 1].

III. In classical inference, the maximum likelihood estimate of μ is always equal to the observed average.

Determine which of the statements above are true.

A. None
B. I and II only
C. I and III only
D. II and III only
E. The answer is not given by (A), (B), (C), or (D)

10.

Suppose an insurer pursues two classes of business in the auto insurance market: class A and class B.

Given the following information:

- There is a 25% chance of writing a policy from class A and 75% chance of writing a policy from class B.
- Claim counts arising from a policy within a class follow a Poisson distribution with annual rate parameters $\lambda_A = 0.30$ and $\lambda_B = 0.05$.
- The insurer writes a policy but does not know to which class the policyholder belongs.
- The insurer experiences one loss from this policy in the first year.
- The policy renews for a second year.

Calculate the probability of the insurer experiencing no losses from this policy in the second year.

A. Less than or equal to 0.70
B. Greater than 0.70 but less than or equal to 0.75
C. Greater than 0.75 but less than or equal to 0.80
D. Greater than 0.80 but less than or equal to 0.85
E. Greater than 0.85

11.

You are given the following data to train a K-Nearest Neighbors classifier with $K = 5$:

X_1	X_2	Y	Distance to $X_1 = 0$, $X_2 = 5$
4	4	Yes	4.1
1	6	No	1.4
7	5	No	7.0
5	5	Yes	5.0
2	7	Yes	2.8
7	2	Yes	7.6
8	4	Yes	8.1
8	6	Yes	8.1
2	3	Yes	2.8
2	5	No	2.0
2	2	Yes	3.6
6	6	No	6.1
1	8	No	3.2
0	5	Yes	0.0

Calculate $\Pr[Y = \text{"Yes"} | X_1 = 0, X_2 = 5]$ with the K-Nearest Neighbors classifier.

A. Less than 0.3
B. At least 0.3, but less than 0.5
C. At least 0.5, but less than 0.7
D. At least 0.7, but less than 0.9
E. At least 0.9

12.

A data set contains six observations for two predictor variables, X_1 and X_2, and a response variable, Y.

X_1	X_2	Y
1	0	1.2
2	1	2.1
3	2	1.5
4	1	3.0
2	2	2.0
1	1	1.6

A regression tree is constructed using recursive binary splitting. A split is denoted

$$R_1(j,s) = \{X|X_1 < s\} \text{ and } R_2(j,s) = \{X|X_1 \geq s\}.$$

The following five splits are analyzed.

I. $R_1(1,1) = \{X|X_1 < 1\}$ *and* $R_2(1,1) = \{X|X_1 \geq 1\}$
II. $R_1(1,4) = \{X|X_1 < 4\}$ *and* $R_2(1,4) = \{X|X_1 \geq 4\}$
III. $R_1(2,0) = \{X|X_2 < 0\}$ *and* $R_2(2,0) = \{X|X_2 \geq 0\}$
IV. $R_1(2,1) = \{X|X_2 < 1\}$ *and* $R_2(2,1) = \{X|X_2 \geq 1\}$
V. $R_1(2,2) = \{X|X_2 < 2\}$ *and* $R_2(2,2) = \{X|X_2 \geq 2\}$

Determine which split is chosen first.

A. I
B. II
C. III
D. IV
E. V

Answer Key

1	E
2	A
3	D
4	B
5	D
6	A
7	C
8	D
9	B
10	D
11	C
12	B