

Technical Test: AI/ML Engineer – Sickbay Healthcare Systems

Test Duration: 3 hours

Context:

You are part of an AI/ML team building real-time predictive models to support clinical decision-making in ICU settings.

Your models will help monitor patient vitals, predict deterioration, and provide early warnings for sepsis and other complications.

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SECTION 1: Data Understanding and Preprocessing (30 pts)

Dataset: You are provided with time-series data of ICU patients including the following:

- Heart Rate (HR)
- Blood Pressure (BP_sys, BP_dia)
- Oxygen Saturation (SpO2)
- Temperature
- Lab values (e.g., WBC, Lactate)
- Demographics
- Timestamped intervention events (e.g., ventilation start, medication given)

Task 1:

Describe how you would handle the following issues in ICU patient data:

1. Missing values
2. Irregular time intervals
3. Anomalies (e.g., sensor dropouts)
4. Outliers caused by temporary disconnections

Provide code snippets (preferably in Python with Pandas/Numpy) where applicable.

SECTION 2: Modeling and Evaluation (40 pts)

Task 2:

You are tasked with building a model to predict the onset of sepsis 6 hours before clinical diagnosis.

Requirements:

- Select an appropriate ML or DL model
- Explain your feature engineering strategy
- Outline how you would deal with class imbalance
- Evaluate model performance (specify metrics)

Deliver: A Jupyter Notebook or script with explanation, plots, and model results. Use mock or real clinical datasets if available (e.g., MIMIC-III/IV, PhysioNet).

SECTION 3: Ethics, Explainability & Deployment (20 pts)

Task 3:

You're deploying your model in a real-time hospital monitoring system. Address the following:

1. How will you ensure model interpretability for clinicians? Mention specific techniques/tools.
2. Describe potential ethical risks or biases in your model. How would you mitigate them?
3. What steps will you take to ensure data privacy and HIPAA compliance?

SECTION 4: Bonus - Real-Time Processing (10 pts)

Task 4:

Your model needs to run in real time, processing patient vitals every minute. Describe how you would architect a streaming pipeline to:

- Ingest data from bedside monitors
- Apply the trained ML model
- Raise alerts on a dashboard

Bonus: Use tools like Kafka, Apache Flink, Spark Streaming, or FastAPI if desired. Diagrams are welcome.

Submission Instructions

- Format: ZIP with code, notebooks, README, and PDF answers
- Deadline: 3 Hours

SECTION 5: Model Deployment Challenges (Optional)

Task 5:

Discuss the challenges you might face when deploying machine learning models in a clinical setting.

Specifically address the following:

1. How would you monitor model drift or degradation over time?
2. What mechanisms would you implement for model version control and rollback?
3. How would you test and validate models in a staging environment before live deployment?
4. What are your strategies for ensuring scalability and fault tolerance in production?

You may include tools or infrastructure components (e.g., Docker, Kubernetes, MLflow, Prometheus).

Real-World Deployment Examples (optional but recommended):

- **Example 1: Sepsis Prediction Pipeline at Hospital X**: Discuss how a real hospital integrated a deep learning model into its EHR system to provide early sepsis warnings. What infrastructure and monitoring tools were used?
- **Example 2: Cloud-based Remote Monitoring**: Explain how cloud services (e.g., AWS Sagemaker, Azure ML, or Google Cloud AI) have been used to deploy patient deterioration models in remote or rural clinics.
- **Example 3: A/B Testing for Risk Scoring Models**: Describe how clinical teams have used A/B testing to validate model improvements without impacting patient safety.

These examples can be sourced from whitepapers, case studies, or your own experience.

SECTION 6: Monitoring Deployed Models (10 pts)

Task 6:

Effective monitoring of deployed models is critical in healthcare environments to ensure safety, accuracy, and compliance.

Answer the following:

1. What metrics would you monitor to assess the performance and stability of a deployed model?
2. How would you detect data drift and concept drift in production?

3. What alerting mechanisms would you use to notify the team when performance degrades?
4. Describe how tools such as Prometheus, Grafana, Evidently AI, or MLflow can support model monitoring.
5. What role do logging and audit trails play in healthcare AI systems, and how would you implement them?

Provide diagrams, pseudocode, or tool recommendations where applicable.

Paper-Based Submission Instructions

Submission Instructions for Paper-Based Test:

1. Write your answers clearly in the spaces provided or on additional sheets.
2. Ensure each answer is labeled with the corresponding question number.
3. Include your full name, contact information, and date on each page.
4. Review your answers to confirm completeness and legibility.
5. Submit the completed test by one of the following methods:
 - Scan and email the document to: submissions@sickbay-ai.com
 - Deliver or mail a physical copy to: Sickbay AI/ML Recruitment, 123 MedTech Blvd, Suite 400, Innovation City, TX 75001
6. Deadline: All submissions must be received by the stated due date on the original test document or accompanying email.

Note: Late or incomplete submissions may not be considered. Please retain a copy of your work for your records.