1. What is BERT and how does it work?
Answer: BERT (Bidirectional Encoder Representations from Transformers) is a transformer-based model designed to pre-train deep bidirectional representations from unlabeled text by jointly conditioning on both left and right context. It uses masked language modeling (MLM) to predict masked tokens and next sentence prediction (NSP) to understand sentence relationships, making it highly effective for various NLP tasks.

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2. What are the main advantages of using the attention mechanism in neural networks?
Answer: The attention mechanism helps models focus on relevant parts of the input, leading to improved performance on tasks with sequential data. It can model long-range dependencies, handle variable-length inputs efficiently, and reduce information loss by assigning varying importance to different input tokens.

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3. How does the self-attention mechanism differ from traditional attention mechanisms?
Answer: Traditional attention computes weights between encoder and decoder outputs in a Seq2Seq framework, focusing on encoder outputs relevant to the current decoding step. Self-attention, in contrast, computes attention weights within the input sequence itself, capturing contextual dependencies between all tokens in the sequence.

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4. What is the role of the decoder in a Seq2Seq model?
Answer: The decoder generates output sequences by processing the context vector from the encoder and previously generated tokens. It predicts the next token step by step, learning the mapping from input sequences to output sequences.

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5. What is the difference between GPT-2 and BERT models?
Answer: GPT-2 is an autoregressive model that generates text by predicting the next word in a sequence, using unidirectional left-to-right context. BERT, on the other hand, is bidirectional and pre-trained to predict masked words and understand relationships between sentences, making it better suited for classification, Q&A, and other tasks requiring contextual understanding.

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6. Why is the Transformer model considered more efficient than RNNs and LSTMs?
Answer: Transformers handle long-range dependencies better using the attention mechanism and process all tokens in parallel, enabling faster training and inference. RNNs and LSTMs process tokens sequentially, making them slower and prone to vanishing gradient issues over long sequences.

7. Explain how the attention mechanism works in a Transformer model.
Answer: In Transformers, the attention mechanism calculates a weighted sum of input embeddings, where the weights are determined by the relevance of each token to others in the sequence. This is done using query, key, and value matrices, enabling the model to attend to different parts of the sequence simultaneously.

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8. What is the difference between an encoder and a decoder in a Seq2Seq model?
Answer: The encoder processes input sequences into a context vector (or representations), which encodes their meaning. The decoder uses this context to generate output sequences one token at a time, predicting each token based on the previous outputs and the encoder's context.

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9. What is the primary purpose of using the self-attention mechanism in transformers?
Answer: The primary purpose of self-attention is to capture contextual relationships between all tokens in an input sequence, enabling the model to understand dependencies regardless of their distance in the sequence.

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10. How does the GPT-2 model generate text?
Answer: GPT-2 generates text by iteratively predicting the next token based on the sequence of tokens it has seen so far. It uses a unidirectional transformer architecture to process inputs from left to right and predict likely continuations.

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11. What is the main difference between the encoder-decoder architecture and a simple neural network?
Answer: An encoder-decoder architecture is designed for sequence-to-sequence tasks, converting input sequences into intermediate representations (via the encoder) and then decoding them into output sequences. A simple neural network lacks this structured approach to handling sequential data and does not explicitly model sequence dependencies.

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12. Explain the concept of “fine-tuning” in BERT.
Answer: Fine-tuning in BERT involves training a pre-trained BERT model on a task-specific dataset with minimal adjustments to the architecture. This allows BERT to adapt its generalized understanding of language to the specific requirements of tasks like sentiment analysis or question answering.

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13. How does the attention mechanism handle long-range dependencies in sequences?
Answer: The attention mechanism assigns weights to all tokens in the sequence based on their relevance to each token being processed. This allows it to efficiently model long-range dependencies by directly linking related tokens regardless of their distance.

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14. What is the core principle behind the Transformer architecture?
Answer: The core principle of the Transformer is its use of self-attention mechanisms to process all input tokens simultaneously, capturing dependencies across the entire sequence. This eliminates the need for sequential token processing, making Transformers highly efficient and effective for long sequences.

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15. What is the role of the "position encoding" in a Transformer model?
Answer: Since Transformers lack inherent sequential processing, position encoding is added to the input embeddings to provide information about the order of tokens. This enables the model to distinguish between tokens in different positions of the sequence.

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16. How do Transformers use multiple layers of attention?
Answer: Transformers stack multiple layers of multi-head self-attention and feedforward networks, enabling the model to learn increasingly abstract and complex relationships across tokens with each subsequent layer.

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17. What does it mean when a model is described as "autoregressive" like GPT-2?
Answer: An autoregressive model predicts the next token in a sequence based on previously generated tokens. This sequential approach ensures that each prediction conditions on all prior outputs.

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18. How does BERT's bidirectional training improve its performance?
Answer: BERT's bidirectional training enables it to learn context from both left and right sides of a word simultaneously, allowing for a deeper understanding of relationships and nuances within text, which improves its performance on language understanding tasks.

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19. What are the advantages of using the Transformer over RNN-based models in NLP?
Answer: Transformers process tokens in parallel, making them faster and more efficient. They also better capture long-range dependencies using self-attention and avoid issues like vanishing gradients and sequential dependency inherent to RNNs.

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20. What is the attention mechanism's impact on the performance of models like BERT and GPT-2?
Answer: The attention mechanism allows these models to focus on relevant parts of the input, handle long-range dependencies effectively, and encode richer contextual information, significantly boosting performance on a variety of NLP tasks.