# Question 1

## Section A

One performance measure in an autonomous driving system for transport vans would be the safety of the vehicle. This is because an autonomous vehicle should be able to complete a journey safely, following all rules fo the road and without any danger to pedestrians or other drivers. Another performance measure would be the completion of deliveries. The autonomous system will be for transport vans, and therefore should be able to complete deliveries within adequate time. A final performance measure would be the destination. The autonomous transport van should be able to arrive at it's intended destination, for the successful completion of deliveries.

## Section B

An autonomous driving system for transport vans in urban environments have a partially observable environment, as the agent may not be able to see every possible variable, such as other cars or pedestrians, or what is around a blind corner while driving. The environment is stochastic, as the actions a self-driving vehicle would take are not the exact same each time. Different routes will need to be planned and different actions will be taken depending on the traffic conditions. The environment is dynamic, as an urban environment will be constantly changing due to many other people interacting with it in different ways on a day to day basis. Finally, the environment is continuous as different routes and sets of actions will be taken for each journey, and number of precise moves the agent will make cannot be predicted.

## Section C

Steering wheel, Accelerator, Brake

## Section D

GPS, Camera, Accelerometer

# Question 2

## Section A

One scenario for an autonomous system for transport vans in urban environments for finding and item in its environment in an optimal way would be to find the shortest possible route to a destination. In this scenario, the autonomous system will need to account for a variety of factors, such as distance from the starting location to the finishing location, time of day, weather, amount of fuel remaining, and traffic conditions to find a route that will allow it to reach its destination in the shortest possible space of time, while maintaining safety and following all rules of the road.

## Section B

In this scenario, an informed search algorithm would be applicable, as the autonomous system will have a GPS as well as other sensors, giving it a heuristic to understand the position towards a goal. One possible search algorithm would be the A\* search algorithm. This algorithm is both complete and optimal, which is preferable to the greedy algorithm, which is neither as it can get stuck in loops. The time complexity of the A\* algorithm is exponential, however within this scenario the system is limited to a single urban environment, and so this may not become an issue. The space complexity is O(b^m), as it keeps all nodes in memory.

## Section C

The heuristic function that could be used for this algorithm would be Manhattan. This function can take into account the total number of both vertical and horizontal moves between the current node and the end node, which would be preferable to functions such as straight-line distance as this is more accurate to the shapes of real world, urban roads.

# Question 3

## Section A

One classification task that this system could employ through supervised learning is the classification of traffic lights on the road and the different colours they may be displaying. The system can be trained on different pictures of traffic lights in various states, with a label. The system could learn to classify the state of the traffic light and what action it should take in response to the colour configuration.

## Section B

An autonomous driving system would be able to detect the colour configurations on a traffic light and react accordingly. For example, if the traffic light was on green, it would be able to classify it as such and make the decision to keep going. If the traffic light was on red, it would make the decision to safely stop the vehicle. If the traffic light was on amber, the system could make the decision to slow down. This requires a logical knowledgebase. An example of what would be stored within the knowledgebase would be “stops(vehicle, red)”, “continues(vehicle, green)”, “slows(vehicle, amber)”.

## Section C

A dataset that could be used for training this classification would be a traffic light configurations dataset, that contains pictures of traffic lights in different possible states. Each image would be labelled with the state the traffic light is representing and could be used to train the system in order to classify various traffic light states. The classes would be “red”, “green”, and “amber”, and this dataset would be fed to the learning by splitting it into a training set and a testing set. The learner could be trained on the training set, and validated on unseen testing data in order to avoid overfitting.

## Section D

One algorithm that could be used for this problem is classification. This algorithm is used for identifying which category an object belongs to, and the feedback given during training is whether the correct category was predicted. This is preferable to regression algorithms as regression is for predicting a continuous valued attribute. Predicting the state of a traffic light is a classification task as there are no continuous valued attributes associated with a traffic light, it can only be in a finite amount of possible states. A specific classification algorithm would be a convolutional neural network. This algorithm can be useful for this task as CNNs excel at image classification in comparison to other approaches, due to the nature of weight sharing which exploits geometric regularities common to typical images. These networks are also faster and less prone to overfitting as they have less parameters.

# Question 4

## Section A

One issue that could be addressed in autonomous driving systems in urban environments through reinforcement learning is safe driving. The system can be rewarded for following rules of the road, such as speed limit and correct stopping in order to learn a policy for maximising its reward. The environment can present issues such as changing speed limit signs and obstacles and emit a reward when the correct action is executed by the agent. When the agent does not follow safe driving etiquette, such as speeding, the reward is not given and therefore the agent will not display that behaviour in future states of the environment.

## Section B

One algorithm that could be applied for the reinforcement learning for this problem is deep Q learning. Q learning is a basic form of reinforcement learning which uses Q-values to iteratively improve the behaviour of the learning agent, by updating the Q-value whenever a state transition occurs depending on the old Q-value, the immediate reward received, and the maximum Q-value achievable in the following state. By repeatedly walking through all nodes the agent is able to backpropagate the results of good and bad actions from terminal nodes to early nodes. However, an issue with simple Q-learning is that they can only handle discrete spaces and continuous variables must be discredited, which is not useful for this problem as the nature of the problem concerns continuous variables within the environment. This issue can be solved with deep Q-learning, which is a neural network that maps input states to action and Q-value pairs. This means more complex functions that have multiple dimensions can be used.

## Section C

One performance measure that could be applied to deep q-learning is the q-value. This denotes the value of taking a specific action in a specific state, and is composed of a present and future reward. The optimal policy can be expressed using q-values, and the strength of the value measures the best-known action in a state.

# Question 5

One of the main principles of responsible AI that can be applied to an autonomous driving system for transport vans in urban environments would be reliability and safety. These kinds of systems have the possibility of risking human life, as autonomous vehicles may malfunction on the road, which is a high-risk situation, and cause collisions. The development of such an application must be subject to rigorous testing and deployment management processes to ensure that they work as expected, with reliability, before they are released into the road.

Another principle of responsible AI is accountability. If an autonomous driving system is involved in a collision while on the road, people should be held accountable. Designers and developers of the AI system should work within a framework of governance and organisational principles that clearly define who is at fault when such an incident occurs and meet legal and ethical standards.

A third principle of responsible AI is transparency. Everything the autonomous driving system is able to do, and all of its limitations should be fully disclosed and made understandable to the general public. If the AI system does not perform as well in night-time conditions than in daytime, for example, then the users of the system should be made aware. This ensures that users do not have unrealistic expectations of the capabilities of the system, ensuring their safety while they may be seated within the van.

A final principle of responsible AI is fairness. The system should treat all people fairly and equally without any bias based on personal attributes or backgrounds. If a collision is unavoidable, for example, the autonomous driving system must not change its course based on the attributes of those around it, choosing to harm one object or person over another based on perceived bias from any physical qualities that it may have accidentally been trained on and learned.