Part 1: Randomness, Theoretical, Experimental and True Probability

With Mathematics and Statistics there are two types of models we can have when looking at situations: **deterministic** and **probabilistic**.

Deterministic models always produce the same result for a particular input. They do not take into account **randomness** and are often expressed as a formula.
An example of this is a formula for compound interest (compounding monthly) is $P\left(1+\frac{r}{12}\right)^n$, where P is the principal, r is the rate of return, and n is the total number of months the money is invested for. If we know what P, r and n are, we can know the amount of money that is in the account. We normally make some assumptions around the situation, for example we are assuming that no other money will be added or removed from the account during the time period.

Probabilistic models take uncertainties into account. This is often done by assigning probabilities to each of the different outcomes. These models take into account **randomness**.
An example of this is flipping a coin. When we flip a coin we can either get heads or tails, and we can work out the probability of each of these events happening.

Randomness is the idea that although each outcome of a process has a fixed probability, the actual outcome of any trial of the process cannot be predicted.

In this paper we focus solely on **probabilistic** models. What we try and do with our **probabilistic** model is estimate the **true probability** of an event occurring.

True probability is the (almost always) unknown actual probability that an event will happen. The **true probability** of a particular coin landing heads up may be affected by the shape of the coin, errors in its manufacture and many other factors, so may not be exactly as we work out.

There are two types of probability we use to estimate the **true probability**… these are: **theoretical probability** and **experimental probability**.

Theoretical probability is what we expect to happen in "theory". If we stay looking at our coin example, we expect that a coin will land on heads 50% of the time, or 0.5. This is a **theoretical** estimate of the **true** probability.

Experimental probability is the probability based on a number of trials or simulations of the event: how many times the event happens divided by the number of trials or simulations we did. The more trials or simulations you do the closer the **experimental probability** will get to the **true probability**, and often it will get close to the **theoretical probability** as well, assuming the theoretical model was a good model. Looking at our coin example, if we took a coin and flipped it 20 times, and 11 of those times it came up with a head, we would have an **experimental probability** of 11/20 or 0.55.

Depending on the situation sometimes it is easier to run a **simulation** rather than doing the trials in real life. This is often done using random number generators on either calculators or computers.

Part 1.1: Answers

Deterministic Model	A model that will always produce the same result for a given set of input values. Does not include elements of randomness.
Experiment	A process or study that results in the collection of data, the outcome of which is unknown.
Experimental Probability	An estimate of the probability that an event will occur calculated from trials of a probability activity by dividing the number of times the event occurred by the total number of trials.
Probabilistic Model	A model that takes uncertainty in outcomes into account. This is often done by associating a probability with each possible outcome.
Randomness	The idea that although each outcome of a process has a fixed probability, the actual outcome of any trial of the process cannot be predicted.
Simulation	A technique for imitating the behaviour of a situation that involves elements of chance or a probability activity.
Theoretical Probability	The probability that an event will occur based on a probability model.
True Probability	The actual probability that an event will occur.