Statistics and Mechanics Year 1

Original practice check

Three short checks on probability, coded data and motion under a constant force. Include units in mechanics answers. Attempt the questions before reading the solutions. These original questions sample selected skills; they are not an official Edexcel paper.

1. Binomial probability

A biased coin has probability $1/3$ of landing heads on each toss. Four tosses are independent. Find the probability of at least one head.

2. Coding and measures of spread

A data set has mean 12 and standard deviation 3. Every value x is replaced by $y = 2x - 5$. Find the mean and standard deviation of the new data set.

3. Newton's second law and constant acceleration

A particle of mass $3\,\text{kg}$ starts from rest on a smooth horizontal surface. A constant horizontal force of $12\,\text{N}$ acts on it. Find its displacement after $4\,\text{s}$.

Find the mistake

A particle has velocity $v = (6 - 2t)\,\text{m s}^{-1}$ for $0 \leq t \leq 5$, with t in seconds. A student finds a displacement of $5\,\text{m}$ and calls this the distance travelled. Find the actual distance.

Further practice: TMUA papers and solutions and maths topic guides.

Hints and worked solutions

1. Binomial probability

Hint: The complement of at least one head is no heads.

The probability of a tail on one toss is $2/3$. Independence means that the probability of four tails is $(2/3)^4 = 16/81$.

Therefore $P(\text{at least one head}) = 1 - 16/81 = 65/81$.

Answer: $\dfrac{65}{81}$.

2. Coding and measures of spread

Hint: A translation changes the centre but not the spread; multiplying every value scales the spread.

The mean transforms in the same way as each value: $\bar{y} = 2\bar{x} - 5 = 2(12) - 5 = 19$.

Subtracting 5 does not change deviations from the mean. Multiplication by 2 doubles their sizes, so the standard deviation is $2(3) = 6$.

Answer: Mean 19; standard deviation 6.

3. Newton's second law and constant acceleration

Hint: Find the acceleration from the horizontal resultant force, then use a constant-acceleration equation.

The surface is smooth, so there is no friction. Vertically, weight and the normal reaction balance. Horizontally, $F = ma$ gives $12 = 3a$, so $a = 4\,\text{m}\,\text{s}^{-2}$.

With $u = 0$ and $t = 4$, $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}(4)(4^2) = 32\,\text{m}$.

Answer: 32 m in the direction of the force.

Find the mistake: correction

The particle changes direction when $6 - 2t = 0$, at $t = 3$. Its displacement over the whole interval is indeed $[6t - t^2]_0^5 = 5\,\text{m}$.

From 0 to 3 seconds it travels $[6t - t^2]_0^3 = 9\,\text{m}$. From 3 to 5 seconds its displacement is $[6t - t^2]_3^5 = -4\,\text{m}$, so it travels a further 4 m.

Total distance is $9 + 4 = 13\,\text{m}$.

What to practise next

1. Write down the random variable and modelling assumptions before calculating a binomial probability.
2. Predict how the mean and spread should change under coding before using a calculator.
3. For mechanics, start with a force diagram, a positive direction and a list of known quantities; check units at the end.