**Hypothesis Testing with the Normal Distribution Exam Questions**

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| The length of a train journey from Norwich to Ipswich follows a normal distribution with a mean of 45 minutes and a standard deviation of 10 minutes. Commuters have complained in recent weeks that journeys are taking longer. A random sample of 36 journeys is taken, which is found to have a mean time of 48 minutes.1. Test at the 5% significance level whether there is evidence of an increase in the train journey time.
2. Using the context of the problem, comment on the suitability of the journey times following a normal distribution.
 |  | The ages of members of a large bowling club is modelled by a normal distribution with a, previously calculated, average age of 61.4 years and standard deviation of 7.5 years.The club secretary is concerned about the ageing membership of the club so takes a random sample of 16 members and finds their mean age to be 65.0 years. 1. Carry out a hypothesis test **by finding the critical region** at the 5% significance level, to determine whether the mean age of club members has changed.
2. Comment on the likely number of members aged under 25, giving a numerical reason for your answer.
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| Scientists believe the mass of narwhals $\~N\left(900,5^{2}\right)$.Fisherman Bob Mortimer thinks the mean mass of Narwhals isn’t 900kg and decides to catch 10 narwhals to test this.Bob catches 10 Narwhals and conducts a hypothesis test at the 5% significant level. He rejects $H\_{0}$, concluding that there is evidence to suggest the mean mass of Narwhals isn’t 900kg.What are the smallest and largest possible mean masses of Bob’s catch? | Stringo Balls, a brand of string, are meant to be sold in lengths of 2m and it is claimed that the lengths follow a normal distribution with mean 2m and standard deviation 0.2m. A trading officer inspects a random sample of 22 balls and finds that the sample has a mean length of 1.91m.Test whether this provides evidence at the 2% significance level, that the mean is less than 2m. | In previous years, marks obtained by students at Top-Notch College have been modelled by a normal distribution with mean 65 and standard deviation 9. Teachers are concerned that this year, students are, on average, underachieving so select a random sample of 35 students whose mean score is found to be 61.5.Investigate the teacher’s suspicion at the 5% level. |

**Writing Frame**

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|  |  | Trains | Narwhals | Stringo Balls | Bowls | Top Notch |
| 1 | Define the variable | $μ=$  | $μ=$  | $μ=$  | $μ=$  | $μ=$  |
| 2 | Write down the null and alternate hypotheses | H0: $μ$ $=$H1: $μ$ | H0: $μ$ $=$H1: $μ$ | H0: $μ$ $=$H1: $μ$ | H0: $μ$ $=$H1: $μ$ | H0: $μ$ $=$H1: $μ$ |
| 3 | What is the significance level? |  |  |  |  |  |
| 4 | Is it one or two tailed? |  |  |  |  |  |
| 5 | Probability of this sample occurring randomly? |  |  |  |  |  |
| 6 | Is this probability less than or greater than the significance level? |  |  |  |  |
| 7 | Accept or reject the null hypothesis? |  |  |  |  |
| 8 | Conclude and clarify in context |  |  |  |  |

**Writing Frame - answers**

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|  |  | Trains | Narwhals | Stringo Balls | Bowls | Top Notch |
| 1 | Define the variable | $μ=$ average train time NOR > IPW | $μ=$ average mass of narwhals | $μ=$ average length of ball of string | $μ=$ average age of bowling members | $μ=$ average marks obtained |
| 2 | Write down the null and alternate hypotheses | H0: $μ$ $=45$ H1: $μ>45$ | H0: $μ$ $=900$H1: $μ\ne 900$ | H0: $μ$ $=2$H1: $μ<2$ | H0: $μ$ $=61.4$H1: $μ\ne 61.4$ | H0: $μ$ $=65$H1: $μ<65$ |
| 3 | What is the significance level? | 5% | 5% | 2% | 5% | 5% |
| 4 | Is it one or two tailed? | One | Two | One | Two | One |
| 5 | Probability of this sample occurring randomly? | $$0.0359$$ | Smallest and largest mean masses are896.9 to 903.1 | $$0.0174$$ | Regions at $57.725$ and $65.075$ | $$0.0107$$ |
| 6 | Is this probability less than or greater than the significance level? | It’s less than | It’s less than | 65 is within the accept $H\_{0}$ region | It’s less than |
| 7 | Accept or reject the null hypothesis? | Reject $H\_{0}$ | Reject $H\_{0}$ | Accept $H\_{0}$ | Reject $H\_{0}$ |
| 8 | Conclude and clarify in context | There is evidence to suggest that average train times are longer than 45 minutes | There is evidence to suggest that average sizes of Stringo balls are smaller than 2m | There is insufficient evidence to suggest that average ages of bowling club members has increased | There is evidence to suggest that students are underachieving  |