WATER, WATER, EVERYWHERE

Get Active!
Use the sample questions below (taken from Scenario #6 in the TEAMS 2009 competition) and see how the questions may change according to level of competition.

Shown are three levels of academic rigor:

- $9^{th}/10^{th}$ level question only (least challenging);
- $9^{th}/10^{th}$ and $11^{th}/12^{th}$ level questions (somewhat challenging); and
- $11^{th}/12^{th}$ level questions only (most challenging).

The challenge per level is based on two factors:

1. The way the assumptions and givens are constructed (their quantity and the way they are expressed).
2. The number of calculations required to answer the question.

Scenario #6: 2009 TEAMS Competition
Keeping Riders Safe in Every Zone of an Amusement Park Megaride

Question Level: Least Challenging, 9th/10th Only

Assumptions and Givens

- For each ride the probability of failure during the lifespan of the ride is 0.25.
- With 54 million rides during the lifespan of a ride the probability of failure per ride is:

$$P(A) = \frac{0.25}{54{,}000{,}000} = 4.6x10^{-9}$$

- There are 25 critical, independent, safety systems (A, B, C, ….,Y) on the ride. If any of the 25 systems fail, the entire ride fails.
- The probability of system A, or B, or C, , or Y failing is given by:
  P(A or B or C ……or Y) = P(A) + P(B) + P(C) + ……+ P(Y).
- Where P(A), P(B) and P(C) are assumed equal to each other. And the joint probabilities were assumed with diminishing small values, and ignored.

Question

To evaluate the overall reliability of the safety systems of a ride, the chance of failure per ride of any given safety system is closest to:

a. $1.28 * 10^{-9}$
b. $4.63 * 10^{-9}$
c. $5.07 * 10^{-11}$
d. $1.85 * 10^{-10}$
e. $8.03 * 10^{-13}$

Answer

Probability of failure for any given system:

$$\frac{4.6x10^{-9}}{25} = 1.85\,x10^{-10}$$

Scenario #6: 2009 TEAMS Competition
Keeping Riders Safe in Every Zone of an Amusement Park Megaride

Question Level: Somewhat Challenging, 9th/10th and/or 11th/12th

Assumptions and Givens

- The new ride, The Screaminator 3,000, can accommodate 54 million rides during its lifespan.
- There are 25 critical, independent, safety systems A, B, C, ….. ,Y on the ride.
- The probabilities of the systems to fail P(A), P(B) and P(C) are assumed equal to each other. And the joint probabilities were assumed with diminishing small values, and ignored.
- There must be no more than a 25% chance of a safety event during the ride's life. (A safety event is an undetected failure of a safety device that may result in the injury of a rider).

Question

The chance of failure per ride of any given safety system is closest to:

a. $1.28 * 10^{-9}$
b. $4.63 * 10^{-9}$
c. $5.07 * 10^{-11}$
d. $1.85 * 10^{-10}$
e. $8.03 * 10^{-13}$

Answer

The probability of failure during the life of the ride is: 25%
Probability of failure per ride is:

$$\frac{0.25}{54{,}000{,}000} = 4.6x10^{-9}$$

The probability of system A, or B, or C…or Y failing is:

$4.6x10^{-9} = P(A)+P(B)+ \bullet \bullet \bullet + P(Y)$

To calculate the overall reliability of the safety systems we calculate the probability of failure for any given system is:

$$\frac{4.6x10^{-9}}{25} = 1.85\,x10^{-10}$$

Scenario #6: 2009 TEAMS Competition
Keeping Riders Safe in Every Zone of an Amusement Park Megaride

Question Level: Most Challenging, 11th/12th Only

Assumptions and Givens

- The new ride, The Screaminator 3,000, will have a capacity of 1,500 riders/hr.
- Assume one rider per car.
- The expected lifespan of the ride is 15 years.
- There must be no more than a 25% chance of a safety event during the ride's life. (A safety event is an undetected failure of a safety device that may result in the injury of a rider.)
- The ride operates 12 hours a day and 200 days a year.
- There are 25 critical, independent, safety systems on the ride.

Question

The chance of failure per ride of any given safety system is closest to:

a. $1.28 * 10^{-9}$
b. $4.63 * 10^{-9}$
c. $5.07 * 10^{-11}$
d. $1.85 * 10^{-10}$
e. $8.03 * 10^{-13}$

Answer

During the life of the ride there will be (1,500)(12)(200)(15) = 54,000,000 rides.

The probability of failure during the life of the ride is: 25%
Probability of failure per ride is:

$$\frac{0.25}{54{,}000{,}000} = 4.6x10^{-9}$$

If any given safety system fails, the ride fails.The probability of system A,B, or C…failing is:

$4.6x10^{-9}$ = P(A)+P(B)+ • • • + P(Y), where,
P(A),P(B),…,P(Y) are equal and the joint probabilities are diminishingly small.

To calculate the overall reliability of the safety systems we calculate the Probability of failure for any given system:

$$\frac{4.6x10^{-9}}{25} = 1.85\,x10^{-10}$$