**OIL WELL**

In an oil well area of Texas are three automatic pumping units that bring the crude oil from the ground. These pumps are installed to operate continuously, 24 hours per day, 365 days per year. Each pump delivers 156 barrels per day of oil when operating normally and the oil is sold at a current price of $42 per barrel. There are times when the pumps stop because of blockages in the feed pipes and severe weather conditions. When this occurs, the automatic controller at the pump wellhead sends an alarm to the maintenance center. Here there is always a crew on-call 24 hours a day. When a maintenance crew is called in there is always a three-person team and they bill the oil company for a fixed 10-hour day at a rate of $62 per hour per crewmember. The data below gives the operating performance of these three pumps in a particular year, for each day of a 365-day year. In the table, “1” indicates the pump is operating. “0” indicates the pump is down (not operating).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Pump No. 1** | | | | | | | | | |  | **Pump No. 2** | | | | | | | | | |  | **Pump No. 3** | | | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |  | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| **Pump No. 1** | | | | | | | | | |  | **Pump No. 2** | | | | | | | | | |  | **Pump No. 3** | | | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |  | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |  | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 |  |  |  |  |  |  | 1 | 1 | 1 | 1 | 1 |  |  |  |  |  |  | 0 | 1 | 1 | 0 | 1 |  |  |  |  |  |

**Required**

Describe this situation in probability and financial terms.

Pump 1:Probabilities:Total number of observations (days) = 365.

Number of 0’s (number of days the pump is down) = 19.

Therefore, number of 1’s (number of days the pump is operating) = 346 (= 365 – 19).

Probability that Pump 1 is down ≈ 0.05206 (= 19/365).

Probability that Pump 1 is operating ≈ 0.94794 (= 346/365).

Finances- Earnings:

Number of barrels of oil produced on each day the pump is working = 156.

Total number of barrels of oil produced by Pump 1 in the 346 days in a year that it is operating = 53,976 (= 346 \* 156).

Total price at which the 53,976 barrels of oil from Pump 1 are sold at $42 per barrel, in the year = $2,266,992.

Finances- Expenses:

Amount paid per hour to each maintenance team member on a day the pump is down = $62.

Number of hours for which each maintenance team member has to be paid on a day the pump is down = 10.

Number of members on the maintenance team = 3.

Total amount paid to all 3 members of the maintenance team on the 19 days the pump is down, for 10 hours on each down-day = $35,340 (= 19 \* 10 \* 3 \* $62).

Finances- Profit:

Total profit made by Pump 1 in the year = $2,231,652 (= Total earnings – Total expenses = $2,266,992 – $35,340).

Pump 2:

Probabilities:

Total number of observations (days) = 365.

Number of 0’s (number of days the pump is down) = 14.

Therefore, number of 1’s (number of days the pump is operating) = 351 (= 365 – 14).

Probability that Pump 2 is down ≈ 0.03836 (= 14/365).

Probability that Pump 2 is operating ≈ 0.96164 (= 351/365).

Finances- Earnings:

Number of barrels of oil produced on each day the pump is working = 156.

Total number of barrels of oil produced by Pump 2 in the 351 days in a year that it is operating = 54,756 (= 351 \* 156).

Total price at which the 54,756 barrels of oil from Pump 2 are sold at $42 per barrel, in the year = $2,299,752.

Finances- Expenses:

Amount paid per hour to each maintenance team member on a day the pump is down = $62.

Number of hours for which each maintenance team member has to be paid on a day the pump is down = 10.

Number of members on the maintenance team = 3.

Total amount paid to all 3 members of the maintenance team on the 14 days the pump is down, for 10 hours on each down-day = $26,040 (= 14 \* 10 \* 3 \* $62).

Finances- Profit:

Total profit made by Pump 2 in the year = $2,273,712 (= Total earnings – Total expenses = $2,299,752 – $26,040).

Pump 3:

Probabilities:

Total number of observations (days) = 365.

Number of 0’s (number of days the pump is down) = 25.

Therefore, number of 1’s (number of days the pump is operating) = 340 (= 365 – 25).

Probability that Pump 3 is down ≈ 0.06849 (= 25/365).

Probability that Pump 3 is operating ≈ 0.93151 (= 340/365).

Finances- Earnings:

Number of barrels of oil produced on each day the pump is working = 156.

Total number of barrels of oil produced by Pump 3 in the 351 days in a year that it is operating = 53,040 (= 340 \* 156).

Total price at which the 53,040 barrels of oil from Pump 3 are sold at $42 per barrel, in the year = $2,227,680.

Finances- Expenses:

Amount paid per hour to each maintenance team member on a day the pump is down = $62.

Number of hours for which each maintenance team member has to be paid on a day the pump is down = 10.

Number of members on the maintenance team = 3.

Total amount paid to all 3 members of the maintenance team on the 14 days the pump is down, for 10 hours on each down-day = $46,500 (= 25 \* 10 \* 3 \* $62).

Finances- Profit:

Total profit made by Pump 3 in the year = $2,181,180 (= Total earnings – Total expenses = $2,227,680 – $46,500).

Comparison:It can be observed that, according to the data on the given year, Pump 2 has the least number of down-days, thus requiring to spend the least amount on maintenance, and producing more oil than any of the other pumps.

Thus, Pump 2 is the most profitable.

On the other hand, Pump 3 has the most number of down days, thus requiring to spend a much larger amount on maintenance, while also producing the least number of barrels of oil in the year.

Thus, Pump 3 is the least profitable.