# ESCUELA SUPERIOR POLITECNICA DEL LITORAL 

Administración de Operaciones<br>Examen Final<br>Term. II, 2018

Yo, $\qquad$ al firmar este compromiso, reconozco que el presente examen está diseñado para ser resuelto de manera individual, que puedo usar una calculadora ordinaria para cálculos aritméticos, un lápiz o esferográfico; que sólo puedo comunicarme con la persona responsable de la recepción del examen; y, cualquier instrumento de comunicación que hubiere traído, debo apagarlo y depositarlo en la parte anterior del aula, junto con algún otro material que se encuentre a compañándolo. No debo además, consultar libros, notas, ni apuntes adicionales a las que se entreguen en esta evaluación. Los temas debo desarrollarlos de manera ordenada. Como estudiante de ESPOL me comprometo a combatir la mediocridad y actuar con honestidad, por eso no copio ni dejo copiar. Firmo al pie del presente compromiso, como constancia de haber leído y aceptar la declaración anterior.

Firma: $\qquad$ Nro.Matrícula. $\qquad$
Paralelo: $\qquad$
1.) Which of the following is the best definition of the inventory position?
a. The amount of inventory on hand.
b. The amount of inventory needed to meet demand during the lead time.
c. The amount of on-hand inventory plus the amount of inventory ordered and waiting to arrive.
d. The amount of inventory ordered and waiting to arrive.
2.) The Williams Manufacturing Company produces wheelchairs. Each wheelchair is made from the following parts: 1 unit of Part A, 2 unit of Part B, and 1 unit of Subassembly C. Each subassembly C is made up of 1 units of Part $\mathrm{D}, 4$ units of Part E , and 3 units of Part F.
a. Develop a material structure tree for wheelchairs.
b. The lead time for each of the parts is one week, except for Part C, which has a lead time of two weeks. The assembly of the completed parts A, B, and C to make the final wheelchair takes one week. Develop a net materials requirements plan for an order of 700 wheelchairs using the following table. Use only the space that you need. Assume that currently only part D has 10 units in inventory that can be used. (Hint: Include Gross, OnHand, Net, Order Receipt, and Order Release.)

|  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |

3.) Oscar is considering the purchase of a new computer system consisting of five separate components. The components are arranged in series with identical reliabilities. The A system with component reliabilities of $75 \%$ costs $\$ 1000$, the B system with component reliabilities of $92 \%$ costs $\$ 2000$, and the C system with component reliabilities of $99 \%$ costs $\$ 5500$. The cost of a failure during a performance is $\$ 45,000$.
a. Calculate the reliability of systems A, B, and C. Which system would you recommend?
b. Oscar has discovered that each system can also be purchased in a configuration where each component has an identical backup, for twice the original cost. Which system would you recommend now?
4.) The ABC Manufacturing Company makes their products in an assembly-line operation. One of the products made has a single assembly line feeding into it. An incomplete unit arrives at the press to be worked on every 8 minutes, on average (Poisson distribution). The machine operator can process an average of 10 parts per hour (exponentially distributed).
a. Determine the average number of parts waiting to be worked on, the percentage of time the operator is working, and the percentage of time the machine is idle.
b. The management team likes to have its operators working $90 \%$ of the time. What must the assembly line arrival rate be in order for the operators to be as busy as management would like?
5.) The Taylor accounting firm has purchased a new computer system. Several activities need to be completed to make sure the system works properly before being used. The following gives information about this project. How long will it take to install the system and what is the critical path?

| Activity | Immediate Predecessor | Time (weeks) |
| :---: | :---: | :---: |
| A | -- | 3 |
| B | -- | 4 |
| C | A | 6 |
| D | B | 2 |
| E | A | 5 |
| F | C | 2 |
| G | D, E | 4 |
| H | E, F | 5 |

## Economic Order Quantity (EOQ) Model and Other Related Equations:

Annual Ordering Cost: Annual Ordering Cost $=\frac{D}{Q} C_{o}$
Annual Holding Cost: Annual Holding Cost $=\frac{Q}{2} C_{h}$
Economic Order Quantity: $E O Q=Q^{*}=\sqrt{\frac{2 D C_{o}}{C_{h}}}$
Average Inventory Level: Average Inventory Level $=\frac{Q}{2}$
Reorder Point when daily demand and lead time are known: $R=d L$
Reorder Point when daily demand is normally distributed, but the lead time is known: $R=\bar{d} L+Z \sigma_{d} \sqrt{L}$
Reorder Point when daily demand is known, but the lead time is normally distributed: $R=d \bar{L}+Z\left(d \sigma_{L}\right)$
Reorder Point when both daily demand and the lead time are normally distributed:
$R=\overline{d L}+Z\left(\sqrt{\bar{L} \sigma_{d}^{2}+\bar{d}^{2} \sigma_{L}^{2}}\right)$
How to find $\mathrm{Z}: Z=\frac{X-\mu}{\sigma}$
Total Annual Holding Cost with Safety Stock: $T H C=\frac{Q}{2} C_{h}+(S S) C_{h}$

## Production Run Model and Other Related Equations

Annual Holding Cost: Annual Holding Cost $=\frac{Q}{2}\left(1-\frac{d}{p}\right) C_{h}$
Annual Setup Cost: Annual Setup Cost $=\frac{D}{Q} C_{S}$
Optimal Production Quantity: $Q^{*}=\sqrt{\frac{2 D C_{S}}{C_{h}\left(1-\frac{d}{p}\right)}}$

## Quantity Discount Model (Equations needed)

EOQ that includes the price $(\mathrm{C}): E O Q=\sqrt{\frac{2 D C_{o}}{I C}}$
Total Cost: $T C=D C+\frac{D}{C} C_{o}+\frac{Q}{2} C_{h}$
Marginal Analysis with Discrete Distributions
Decision Rule: $P \geq \frac{M L}{M P+M L}$

## Equations Related to Design of Goods and Services

$$
\begin{gathered}
\text { MTBF } \equiv \text { Mean Time Between Failures } \\
M T T R \equiv \text { Mean Time to Repair }
\end{gathered}
$$

System Availability: $S A=\frac{M T B F}{M T B F+M T T R}$

## Waiting Line Analysis Equations:

$$
\begin{aligned}
& \lambda \equiv \text { Mean Arrival Rate } \\
& \mu \equiv \text { Mean Service Rate }
\end{aligned}
$$

The probability that no customers are in the queuing system (either in the queue or being served): $P_{0}=\left(1-\frac{\lambda}{\mu}\right)$
The probability of exactly n customers in the queuing system: $P_{n}=\left(\frac{\lambda}{\mu}\right)^{n} \cdot P_{0}$
The average number of customers in the queuing system (i.e., the customers being serviced and in the waiting line): $L=\frac{\lambda}{\mu-\lambda}$
The average number of customers in the waiting line: $L_{q}=\frac{\lambda^{2}}{\mu(\mu-\lambda)}$
The average time a customer spends in the queuing system (i.e., waiting and being served): $W=\frac{1}{\mu-\lambda}$
The average time a customer spends waiting in line to be served: $W_{q}=\frac{\lambda}{\mu(\mu-\lambda)}$
The probability that the server is busy and a customer has to wait, known as the utilization factor: $\rho=\frac{\lambda}{\mu}$
The probability that the server is idle and a customer can be served: $I=1-\rho$

## Equations Related to Sales and Ope rations Planning

Optimal Probability of Demand or No-Shows $=\frac{C_{u}}{C_{u}+C_{o}}$
Where Cost of Underbooking or Underestimating demand $\equiv C_{u}$ and Cost of Overbooking or Overestimating Demand $\equiv C_{o}$

## Equations Related to Project Management

Expected Activity Time: $t=\frac{a+4 m+b}{6}$
Variance of Activity Completion Time: Variance $=\left(\frac{b-a}{6}\right)^{2}$
Earliest Finish Time: $E F=E S+t$
Latest Start Time: $L S=L F-t$
Slack: Slack $=L S-E S$ or Slack $=L F-E F$
Project Variance: Project Variance $=\sum$ Variance of Activities on the Critical Path
Project Standard Deviation: Project Standard Deviation $=\sqrt{\text { Project Variance }}$

Value of Work Completed:
Value of Work Completed $=($ Percent of work completed $) *($ Total Activity Budgeted $)$
Activity Difference:Activity Difference $=$ Actual Cost - Value of Work Completed
Crash Cost per Time Period: Crash Cost per Time Period $=\frac{\text { Crash Cost-Normal Cost }}{\text { NormalTime-CrashTime }}$

|  | 00 | . 01 | . 02 | . 03 | . 04 | . 05 | . 06 | . 07 | . 08 | . 09 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0.0 | . 50000 | . 50399 | . 50798 | 51197 | . 51595 | . 51994 | . 52392 | . 52790 | . 53188 | 53586 |
| 0.1 | 53983 | . 54380 | . 54776 | 55172 | . 55567 | . 55962 | . 56356 | S6749 | 57142 | 57535 |
| 0.2 | 57926 | . 58317 | . 58706 | 59095 | . 59483 | . 59871 | . 60057 | . 60642 | . 61026 | . 61409 |
| 0.3 | . 61791 | . 62172 | . 62552 | . 62930 | . 63307 | . 63683 | . 64058 | . 64431 | . 64803 | 65173 |
| 0.4 | . 65542 | . 65910 | . 60276 | . 66640 | . 67003 | . 67364 | . 67724 | . 68082 | . 68439 | . 68793 |
| 0.5 | . 69146 | . 69497 | . 69847 | . 70194 | . 70540 | . 70884 | . 71226 | . 71566 | . 71904 | .72240 |
| 0.6 | . 72575 | . 72907 | . 73237 | . 73536 | . 73891 | . 74215 | . 74537 | . 74857 | . 75175 | .75490 |
| 0.7 | . 75804 | . 76115 | . 76424 | . 76730 | . 77035 | . 77337 | .77637 | .77935 | . 78230 | . 78524 |
| 0.8 | . 78814 | . 79103 | . 79389 | . 79673 | . 79955 | . 80234 | . 80511 | . 80785 | . 81057 | . 81327 |
| 0.9 | 81594 | . 81859 | . 82121 | \$2381 | . 82639 | . 82894 | . 83147 | 83398 | 83646 | 83891 |
| 1.0 | . 84134 | . 84375 | 84614 | 84849 | . 85083 | . 85314 | . 85543 | . 85769 | . 85993 | \$6214 |
| 1.1 | . 86433 | .86650 | . 86864 | . 87076 | . 87286 | . 87493 | . 87698 | . 87900 | .88100 | .88298 |
| 1.2 | 88493 | . 88686 | . 88877 | \$9065 | . 89251 | . 89435 | 89617 | . 89796 | . 89973 | S0147 |
| 1.3 | .90320 | . 90490 | . 90658 | . 90824 | .90988 | .91149 | . 91309 | . 91466 | . 91621 | 91774 |
| 1.4 | 91924 | . 92073 | . 92220 | 92364 | 92507 | .92647 | . 92785 | 92922 | . 93056 | . 93189 |
| 1.5 | 93319 | . 93448 | . 93574 | 93699 | 93822 | 93943 | . 94062 | . 94179 | . 34295 | .94408 |
| 1.6 | 94520 | . 94630 | . 947738 | . 94845 | . 94950 | . 95053 | . 95154 | . 95254 | . 95352 | . 95449 |
| 1.7 | 95543 | . 95637 | . 95728 | . 95818 | . 95907 | 95994 | .96080 | . 96164 | .96246 | 96327 |
| 1.8 | . 96407 | . 96485 | . 96562 | .96638 | . 96712 | 96784 | . 96856 | 96926 | . 96995 | . 97062 |
| 1.9 | . 97128 | . 97193 | . 97257 | . 97320 | . 97381 | . 97441 | . 97500 | . 97558 | . 97615 | 97670 |
| 2.0 | . 97725 | . 97784 | . 97831 | . 97882 | . 97932 | 97982 | . 98030 | .98077 | .98124 | 98109 |
| 2.1 | . 98214 | . 98257 | . 98300 | . 98341 | . 98382 | 98422 | . 98461 | . 98500 | . 98537 | .98574 |
| 2.2 | . 98610 | . 98645 | . 98679 | . 98713 | . 98745 | . 98778 | . 98809 | . 98840 | .98870 | . 98899 |
| 2.3 | 98928 | . 98956 | 98983 | 99010 | . 99036 | 99061 | . 99086 | 99111 | .99134 | 99158 |
| 2.4 | . 99180 | . 99202 | . 99224 | . 99245 | . 99266 | 99286 | . 99305 | . 99924 | . 99343 | . 99361 |
| 2.5 | . 99379 | . 99396 | 99413 | 99430 | . 99446 | 99461 | .99477 | 99492 | . 99506 | 99520 |
| 2.6 | 99534 | . 99547 | 99560 | 99573 | . 99585 | 99598 | . 99609 | 99621 | . 99632 | 99643 |
| 2.7 | 99653 | . 99664 | . 99674 | 99683 | .99693 | 99702 | .99711 | 99720 | . 99728 | 99736 |
| 2.8 | . 99744 | . 99752 | 99760 | 99767 | . 99774 | 99781 | .99788 | S9795 | .99801 | 99807 |
| 2.9 | 99813 | . 99819 | 99825 | 99831 | . 99836 | 99841 | . 99846 | 99851 | .99856 | 99861 |
| 3.0 | 99865 | . 99869 | 99874 | 99878 | 99882 | 99886 | . 99889 | 99893 | . 99896 | 99900 |
| 3.1 | . 99903 | . 99906 | . 99910 | . 99913 | .99916 | . 99918 | . 99921 | .99924 | .99926 | . 99929 |
| 3.2 | .99931 | . 99934 | . 99936 | . 99938 | .99940 | . 99942 | . 99944 | . 99946 | . 999448 | . 999950 |

