# ESCUELA SUPERIOR POLITECNICA DEL LITORAL

Administración de Operaciones
Examen Final
Term. I, 2018

*Yo, ……, 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 acompañándolo. 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: …… Nro.Matrícula: ……*

*Paralelo: ……..*

1.) Flora's Flower Shop has decided to determine the safety stock and reorder point (ROP) for their blue vases. The daily demand for the vase is normally distributed, with a mean of 9 and a standard deviation of 2. The lead time is exactly 4 days. Flora's Flower shop would like to maintain a 95% service level. What is the reorder point, and how much safety stock should be carried? *(Flora's Flower Shop ha decidido determinar el stock de seguridad y el punto de reorden (ROP) para sus jarrones azules. La demanda diaria del jarrónes se distribuye normalmente, con una media de 9 y una desviación estándar de 2. El tiempo de entrega es exactamente de 4 días. La floristería de Flora desea mantener un nivel de servicio del 95%. ¿Cuál es el punto de reorden y cuánto stock de seguridad se debe llevar?)*

2.) True or False: Reliability refers to the ease and/or cost with which a product or service is maintained or repaired. *(Verdadero o falso: la confiabilidad se refiere a la facilidad y / o costo con el cual un producto o servicio se mantiene o se repara.)*

3.) Annie Smith is a nurse on the evening shift from 10:00 P.M. to 6:00 A.M. at Community Hospital. She averages 5 calls from her patients every hour (Poisson distributed), and she must spend an average of 10 minutes (negative exponential distribution) with each patient who calls. Nurse Smith has indicated to her shift supervisor that although she has not kept records she believes her patients must wait about 10 minutes on average for her to respond and she has requested that her supervisor assign a second nurse to her area. The supervisor believes 10 minutes is too long to wait, but she does not want her nurses to be idle more than 40% of the time. Determine if the supervisor should hire another nurse to help. (You must have the correct average time a patient spends waiting in line to be served and probability that the nurse will be idle to get full points). *(Annie Smith es enfermera en el turno de noche de 10:00 p.m. a las 6:00 a.m. en Community Hospital. Promedia 5 llamadas de sus pacientes cada hora (Poisson distribuido), y debe pasar un promedio de 10 minutos (distribución exponencial negativa) con cada paciente que llama. La enfermera Smith le ha indicado a su supervisor de turno que, aunque no ha llevado registros, cree que sus pacientes deben esperar aproximadamente 10 minutos en promedio para que ella responda y ha solicitado que su supervisor le asigne una segunda enfermera a su área. El supervisor cree que 10 minutos son demasiado largos para esperar, pero no quiere que sus enfermeras permanezcan inactivas más del 40% del tiempo. Determine si el supervisor debe contratar a otra enfermera para que lo ayude. (Debe tener el tiempo promedio correcto que un paciente pasa esperando en línea para recibir el servicio y la probabilidad de que la enfermera esté inactiva para obtener puntos completos).)*

*4.)* A company is trying to determine what kind of strategy to use in their sales and operations planning. Their hiring costs are $70 per person, their firing costs are $80 per person. It costs them $1.50 to hold an item in inventory to the next period and their production costs are $4 per unit. Each worker can produce 200 units per period. We begin with 300 workers. There are four periods. Period 1 has a demand of 5,000 units; period 2 has a demand of 3,000 units; Period 3 has a demand of $4000 units; and period 4 has a demand of 2,000 units. Each worker gets a salary of $1,500 per period. There is no starting inventory. Write a linear programming problem for this company where they are minimizing their costs. Be sure to label your decision variables and include all constraints. *(Una compañía está tratando de determinar qué tipo de estrategia usar en su planificación de ventas y operaciones. Sus costos de contratación son de $ 70 por persona, sus costos de despido son de $ 80 por persona. Les cuesta $ 1.50 mantener un artículo en el inventario para el próximo período y sus costos de producción son de $ 4 por unidad. Cada trabajador puede producir 200 unidades por período. Comenzamos con 300 trabajadores. Hay cuatro periodos El Período 1 tiene una demanda de 5,000 unidades; el período 2 tiene una demanda de 3.000 unidades; El Período 3 tiene una demanda de $ 4000 unidades; y el período 4 tiene una demanda de 2,000 unidades. Cada trabajador recibe un salario de $ 1,500 por período. No hay inventario inicial. Escriba un problema de programación lineal para esta empresa que está minimizando sus costos. Asegúrese de etiquetar sus variables de decisión e incluir todas las restricciones.)*

5.) For the following project and corresponding activities, find the ES, LS, EF, LF, critical path, and expected project completion time. *(Para el siguiente proyecto y las actividades correspondientes, encuentre el ES, LS, EF, LF, la ruta crítica y el tiempo de finalización del proyecto esperado.)*

| Activity *(Actividad)* | Predecessor *(Predecesor)* | Expected Time *(Tiempo Esperado)* | ES | LS | EF | LF |
|---|---|---|---|---|---|---|
| A | - | 7 | | | | |
| B | - | 7 | | | | |
| C | - | 4 | | | | |
| D | A,B | 4 | | | | |
| E | C | 8 | | | | |
| F | D | 2 | | | | |
| G | E | 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: $EOQ = Q^* = \sqrt{\frac{2DC_o}{C_h}}$

Average Inventory Level: $Average\ Inventory\ Level = \frac{Q}{2}$

Reorder Point when daily demand and lead time are known: $R = dL$

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: $R = d\bar{L} + Z(d\sigma_L)$

Reorder Point when both daily demand and the lead time are normally distributed:
$R = \bar{d}\bar{L} + Z\left(\sqrt{\bar{L}\sigma_d^2 + \bar{d}^2\sigma_L^2}\right)$

How to find Z: $Z = \frac{X-\mu}{\sigma}$

Total Annual Holding Cost with Safety Stock: $THC = \frac{Q}{2}C_h + (SS)C_h$

**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: $Q^* = \sqrt{\frac{2DC_S}{C_h\left(1-\frac{d}{p}\right)}}$

**Quantity Discount Model (Equations needed)**

EOQ that includes the price (C): $EOQ = \sqrt{\frac{2DC_o}{IC}}$

Total Cost: $TC = DC + \frac{D}{C}C_o + \frac{Q}{2}C_h$

**Marginal Analysis with Discrete Distributions**

Decision Rule: $P \geq \frac{ML}{MP+ML}$

**Equations Related to Design of Goods and Services**

$$MTBF \equiv Mean\ Time\ Between\ Failures$$

$$MTTR \equiv Mean\ Time\ to\ Repair$$

System Availability: $SA = \frac{MTBF}{MTBF+MTTR}$

**Waiting Line Analysis Equations**:

$$\lambda \equiv Mean\ Arrival\ Rate$$

$$\mu \equiv Mean\ Service\ Rate$$

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 Operations 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: $t = \frac{a+4m+b}{6}$

Variance of Activity Completion Time: $Variance = \left(\frac{b-a}{6}\right)^2$

Earliest Finish Time: $EF = ES + t$

Latest Start Time: $LS = LF - t$

Slack: $Slack = LS - ES\ or\ Slack = LF - EF$

Project Variance: $Project\ Variance = \sum Variance\ of\ Activities\ on\ the\ Critical\ Path$

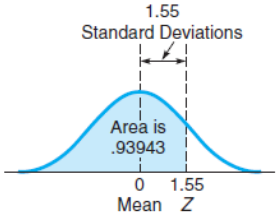
Project Standard Deviation: $Project\ Standard\ Deviation = \sqrt{Project\ Variance}$

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: $Crash\ Cost\ per\ Time\ Period = \frac{Crash\ Cost - Normal\ Cost}{Normal\ Time - Crash\ Time}$

## Appendix A: Areas Under the Standard Normal Curve




**Example:** To find the area under the normal curve, you must know how many standard deviations that point is to the right of the mean. Then the area under the normal curve can be read directly from the normal table. For example, the total area under the normal curve for a point that is 1.55 standard deviations to the right of the mean is .93943.

| | 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 | .56749 | .57142 | .57535 |
| 0.2 | .57926 | .58317 | .58706 | .59095 | .59483 | .59871 | .60257 | .60642 | .61026 | .61409 |
| 0.3 | .61791 | .62172 | .62552 | .62930 | .63307 | .63683 | .64058 | .64431 | .64803 | .65173 |
| 0.4 | .65542 | .65910 | .66276 | .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 | .82381 | .82639 | .82894 | .83147 | .83398 | .83646 | .83891 |
| 1.0 | .84134 | .84375 | .84614 | .84849 | .85083 | .85314 | .85543 | .85769 | .85993 | .86214 |
| 1.1 | .86433 | .86650 | .86864 | .87076 | .87286 | .87493 | .87698 | .87900 | .88100 | .88298 |
| 1.2 | .88493 | .88686 | .88877 | .89065 | .89251 | .89435 | .89617 | .89796 | .89973 | .90147 |
| 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 | .94295 | .94408 |
| 1.6 | .94520 | .94630 | .94738 | .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 | .98169 |
| 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 | .99324 | .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 | .99795 | .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 | .99948 | .99950 |