University of Jordan
Department of Industrial Engineering
First Exam (20%) of Reliability Course (summer 2023)
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Student Name: -- **ID #:** ----------------------------

Q1 (6 pts: 10 minutes) Please fill in the missing terms/phrases in the blank:

1. The Concept FMEA helps select the optimal design and determine if redundancy is required.
2. The useful life is the estimated economic life of the product.
3. The QFD ensures that the customer's voice is captured and that a realistic set of reliability requirements is deployed.
4. Criticality indicates much more than severity×occurrence in military standards.
5. The Unintended function is indicated when the interaction of several elements whose independent performance is correct adversely impacts the product when synergy exists.
6. When severity is major, the reliability target will be 95%
7. The early fracture of materials due to substandard specification on material or geometry is an example of design deficiency
8. Confirmation by examination and provision of objective evidence that specified requirements have been fulfilled is the definition of ~~Ver~~ verification
9. The Wearout phase is characterized by an increasing failure rate.
10. Intermittent function is one category of the failure mode

Q2 (14 pts: 35 minutes) The battery life of a video game was studied. Consider the following cases **separately:**

- The time-to-failure is satisfactorily modeled by an **exponential** distribution with a **mean time to failure**= 100 hours. Calculate the probability that the battery will **survive** before 90 hours. ***Answer***: 0.406

$\theta = 100$

$t = 90$

$$R(t) = e^{-\frac{t}{\theta}}$$

$$= e^{-0.9} = 0.406$$

- The time to failure of the battery is modeled by a **Normal** distribution of mean and standard deviation of 100 and 2, respectively. If $p(z \le 2) = 0.97725$. **Calculate the hazard function value** at this time (=104 hours). ***Answer***: ~~1.~~19--

$$h(104) = \frac{\phi(2)}{\sigma R(104)} = \frac{0.054}{2(0.02275)} = 1.19$$

$$R(t) = 0.02275$$

$$\phi(2) = \frac{1}{\sqrt{2\pi}} \cdot \exp\left(-\frac{z^2}{2}\right) = 0.054$$

- The hazard function for an electronic component is given by:

$$h(t) = \frac{0.25 \times t^{-0.75}}{400 \times 400^{-0.75}}$$

Calculate the reliability of the component at 200 hours. ***Answer***: 0.431

$\beta = 0.25$

$\theta = 400$

$$R(200) = \exp^{-\left(\frac{200}{400}\right)^{0.25}} = 0.431$$

- A manufacturer of electronic calculators offers a warranty **of 6 months**. If the calculator fails for any reason during this period, it is replaced. The calculator's time to failure is well modeled by the following probability distribution (***t*** in **years**):

$$f(x) = 0.15\ exp\ -0.15t$$

If 100 calculators were produced. How many calculators are expected **to fail before** the warranty life? ***Answer***: --8-

$\lambda = 0.15$

$$R(t) = e^{-0.15 \times 0.5} = 0.9277$$

$$F(t) = 0.0723$$

Exp. Calculators to fail $= 0.0723 \times 100$
$= 7.23 \simeq \boxed{8}$

$$\text{MTTF} = \frac{r}{\lambda} \Rightarrow \lambda = 0.01 \qquad (300,\ 3)$$

- An electronic component has the following reliability function at 100 hours:

$$R(100) = \sum_{x=0}^{2} \frac{(100\Omega)^x \ .exp - (100\Omega)}{x!}$$

$$R(t) = e^{-\lambda t}\left[1 + \lambda t + \frac{(\lambda t)^2}{2}\right] = 0.9197$$

$$h(t) = \frac{f(t)}{R(t)} = \frac{\frac{0.01^3}{2} \times 100^2 \cdot e^{-0.01 \times 100}}{0.9197} = \boxed{0.002}$$

where Ω *is constant rate.* If the mean time to failure of the distribution = 300 hours Calculate the value of the corresponding **hazard function at 100 hours**. ***Answer***: --0.002

$$0.002 = \frac{1.839 \times 10^{-3}}{0.9197}$$

$$\cancel{R(t) = 0.02275 = 1 - P(Z \le 2)}$$

$$\cancel{h(t) = \frac{\phi(2)/\sigma}{R(t)} = \frac{0.05399}{2 \times 0.02275} = 1.186 \approx 1.19}$$

$$\cancel{\phi(2) = \frac{1}{2\pi} \exp\left(\frac{-z^2}{2}\right) = 0.054}$$

- The battery that has a time-to-failure modeled by an **exponential** distribution with a mean time to failure= 100 hours will be replaced by an equivalent battery that has a time-to-failure modeled by **Weibull** distribution with shape parameter = 0.5. Calculate the **scale parameter of the distribution** such that the reliabilities of both batteries are equal at 100 hours. ***Answer***: ----~~0.4934~~ 100 hrs

$$R(t) = e^{-\lambda t} = e^{-(t/\theta)^{\beta}} \Rightarrow -1 = -\left(\frac{100}{\theta}\right)^{0.5}$$

$$t = 100 \qquad \lambda = 0.01 \qquad \theta^{1/2} = 100^{0.5}$$

$$\boxed{\theta = 100}$$

$$\boxed{\theta = 100}$$

- The battery has a time-to-failure modeled by an exponential distribution. The battery's probability of survival *t* hours = 0.8. If a **charging unit** is composed of two identical and independent of such battery that are connected in a standby redundant configuration. Calculate the **probability that the unit survives *t* hours.** ***Answer***: --0.979

$$e^{-\lambda t} = 0.8$$

$$\lambda t = \ln 0.8$$

$$R(t) = e^{-\lambda t}\left[1 + \lambda t\right] = 0.8 \times \left[1 - \ln 0.8\right] = 0.979$$