EXAM SOLUTION

Exercise 1: True or False (with justification) : (05 pt)

1. A reliable asset requires less maintenance than others.	**False (0.25)**	A reliable asset may **still require regular preventive maintenance** to maintain its reliability. Less frequent failure does not imply less maintenance. **(0.75)**
2. Corrective maintenance is scheduled at regular intervals.	**False (0.25)**	Corrective maintenance is performed **after a failure occurs**, not scheduled in advance like preventive maintenance. **(0.75)**
3. MTBF applies only to repairable systems.	**True (0.25)**	MTBF (Mean Time Between Failures) is used for **repairable systems**, while MTTF is used for non-repairable systems. **(0.75)**
4. The bathtub curve models the reliability rate over time.	**True (0.25)**	The **bathtub curve** represents the failure rate over time, with three phases: early failures, constant failure rate, and wear-out failures **(0.75)**
5. TPM is a preventive maintenance technique reserved for automated machines.	**False (0.25)**	**Total Productive Maintenance (TPM)** involves **all employees** and is not limited to automated machines; it promotes proactive and preventive maintenance. **(0.75)**

Exercise 2 : (05 pt)

Given: (Total operating time = 1,000 hours) (Number of failures = 5) (MTTR = 4 hours)	
1. Calculate MTBF and MTTF	MTBF = Total operating time / Number of failures = 1000 / 5 = 200 hours **(0.5)** Since it's a repairable system, MTTF = MTBF – MTTR = 200 – 4 = 196 hours **(0.5)**
2. Deduce the failure rate λ	**Failure rate λ = 1 / MTBF** = 1 / 200 = 0.005 failures/hour **(1)**
3. The equipment availability	**Availability = MTBF / (MTBF + MTTR)** = 200 / (200 + 4) ≈ 0.9804 or 98.04% **(1)**
4. If MTTR = 2 h, new availability	**Availability = 200 / (200 + 2)** ≈ 0.9901 or 99.01% **(1)**
5. Reliability R(t) over 100 hours	Use: **$R(t) = e^{(-\lambda t)}$** = $e^{(-0.005\times100)} = e^{(-0.5)} \approx 0.6065$ or 60.65% **(1)**

Exercise 3 : (03 pt)

1. Branch 1 (Series): $R_1 = 0.95$, $R_2 = 0.92$ **Branch 2**:	Series reliability = $\mathbf{R_1 \times R_2} = 0.95 \times 0.92 = \mathbf{0.874}$ **(1)** $R_3 = 0.90$
2. System (parallel branches): System reliability $= \mathbf{1 - [(1 - R_{branch1}) \times (1 - R_{branch2})]}$	$R_{sys} = 1 - [(1 - 0.874) \times (1 - 0.90)] = 1 - 0.0126 = \mathbf{0.9874}$ **(1)**
3. If R3 improves to 0.98:	New $R_{sys} = 1 - [(1 - 0.874) \times (1 - 0.98)] = 1 - 0.00252 = \mathbf{0.9975}$ **(0.5)**
Improving R3 from 0.90 to 0.98 **significantly increases** system reliability. **(0.5)**	

Exercise 4: OEE Calculation : (07 pt)

Given: (Total planned time = 80 hours) (Downtime = 5 hours) (Minor stops and slowdowns = 6 hours) (Actual production = 9,500 units) (Ideal speed = 150 units/hour) (Defective units = 400)	
Availability	Operating time = 80 − 5 = **75 hours** **(0.5)**
	Availability = **Operating time / Planned time** = 75 / 80 = **0.9375 or 93.75%** **(0.5)**
Performance	Net operating time = 75 − 6 = 69 hours **(0.5)**
	Ideal production = 150 × 69 = 10,350 units **(0.5)**
	Performance = **Actual production / Ideal production** = 9500 / 10350 ≈ **0.9174 or 91.74%** **(1)**
Quality	Good units = 9500 − 400 = 9100 **(0.5)**
	Quality = **Good units / Actual production** = 9100 / 9500 ≈ **0.9579 or 95.79%** **(0.5)**
OEE	OEE = **Availability × Performance × Quality** = 0.9375 × 0.9174 × 0.9579 ≈ **0.8235 or 82.35%** **(1)**
Ideal production (100% OEE)	Ideal production = 80 hours × 150 units/hour = **12,000 units** **(1)**
Improvement suggestions	1. **Reduce downtime** through better preventive maintenance. **(0.5)** 2. **Improve quality control** to reduce defective units. **(0.5)**