

## MODULE DESCRIPTION FORM

## نموذج وصف المادة الدراسية

| Module Information                 |                                           |                               |                                                                                                                                                                                                                                                     |                        |
|------------------------------------|-------------------------------------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| معلومات المادة الدراسية            |                                           |                               |                                                                                                                                                                                                                                                     |                        |
| Module Title                       | Cloud Computing                           |                               | Module Delivery                                                                                                                                                                                                                                     |                        |
| Module Type                        | Core                                      |                               | <input checked="" type="checkbox"/> Theory<br><input checked="" type="checkbox"/> Lecture<br><input checked="" type="checkbox"/> Lab<br><input type="checkbox"/> Tutorial<br><input type="checkbox"/> Practical<br><input type="checkbox"/> Seminar |                        |
| Module Code                        | CET4204                                   |                               |                                                                                                                                                                                                                                                     |                        |
| ECTS Credits                       | 5                                         |                               |                                                                                                                                                                                                                                                     |                        |
| SWL (hr/sem)                       | 150                                       |                               |                                                                                                                                                                                                                                                     |                        |
| Module Level                       | 4                                         | Semester of Delivery          |                                                                                                                                                                                                                                                     | 8                      |
| Administering Department           | CET                                       | College                       | EETC                                                                                                                                                                                                                                                |                        |
| Module Leader                      | Osama Abbas Hussein                       |                               | e-mail                                                                                                                                                                                                                                              | Osama.abbas@mtu.edu.iq |
| Module Leader's Acad. Title        | Lecturer                                  | Module Leader's Qualification | PhD                                                                                                                                                                                                                                                 |                        |
| Module Tutor                       | Ali Nafaa Gaafar                          |                               | e-mail                                                                                                                                                                                                                                              | ali_nafaa@mtu.edu.iq   |
| Peer Reviewer Name                 | Asst. Prof.<br>Alhamzah Taher<br>Mohammed |                               | e-mail                                                                                                                                                                                                                                              | alhamza_tm@mtu.edu.iq  |
| Scientific Committee Approval Date | 13/06/2023                                | Version Number                | 1.0                                                                                                                                                                                                                                                 |                        |

| Relation with other Modules       |      |          |  |
|-----------------------------------|------|----------|--|
| العلاقة مع المواد الدراسية الأخرى |      |          |  |
| Prerequisite module               | None | Semester |  |
| Co-requisites module              | None | Semester |  |

| <b>Module Aims, Learning Outcomes and Indicative Contents</b><br><b>أهداف المادة الدراسية ونتائج التعلم والمحتويات الإرشادية</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Module Aims</b><br><b>أهداف المادة الدراسية</b>                                                                               | <ol style="list-style-type: none"> <li>1. To define the concept of hosting</li> <li>2. To introduce the cloud-computing paradigm</li> <li>3. To simplify the transition from bare-metal servers thinking to a cloud-native approach.</li> <li>4. To foster the automation and orchestration concepts.</li> <li>5. To design, build and manage private clouds.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Module Learning Outcomes</b><br><b>مخرجات التعلم للمادة الدراسية</b>                                                          | <ol style="list-style-type: none"> <li>1. Classify cloud hosting types.</li> <li>2. Describe the data center infrastructure.</li> <li>3. Utilization of virtual machines</li> <li>4. Transition into virtual networking.</li> <li>5. Management of cloud infrastructure.</li> <li>6. Comprehension of cloud-storage</li> <li>7. Correct utilization of micro-services.</li> <li>8. Proper use of rate-limiting concepts.</li> <li>9. Understanding the concept of security.</li> <li>10. Understanding the concept of privacy.</li> <li>11. Capability to diagnose bottlenecks in cloud-based systems.</li> <li>12. Proper application of concepts of elasticity in production systems.</li> </ol>                                                                                                                                                                                                                                                                                                                                           |
|                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Indicative Contents</b><br><b>المحتويات الإرشادية</b>                                                                         | <p>Indicative content includes the following:</p> <ul style="list-style-type: none"> <li>-<b>Cloud Computing History</b> – Power wall, Cloud Computing physical component and organization, cloud computing services. [5 hr.s]</li> <li>-<b>Cloud Computing types</b> – Private and Public Cloud, Hybrid and Multi-Cloud, Hyperscale's, and Cloud server selection. [5 hr.s]</li> <li>-<b>Data Centers</b> – Racks, aisles, Pods, Cloud networking and power management, North-South and East-West Networks, Fat Tree design, leaf-spine scaling. [5 hr.s]</li> <li>-<b>VM and Containers</b> – Virtualization, Hypervisor, Container and Docker software components. [5 hr.s]</li> <li>-<b>Virtual Network and Virtual Storage</b> – Overlays and Underlays, VLANs and VXLANs, SDN and OpenFlow Protocol, Programmable Network. [10 hrs.]</li> <li>-<b>consensus</b> – Need of agreement in cloud-based systems, types, challenges. [10 hrs.]</li> <li>-<b>Cloud-storage</b>– traditional vs software designed storage. [5 hr.s]</li> </ul> |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p><b>-Microservices-</b> Monolithic Apps in Data Centers, The Microservices Approach: Pros and Cons, Microservices Granularity, Communication Protocols for Microservices, Service Mesh Proxy, Microservices Technologies. [5 hr.s]</p> <p><b>-Serverless Computing</b> – The serverless Computing Approach, Stateless Servers and Containers, Serverless Infrastructure, an Example of Serverless Processing. [10 hr.s]</p> <p><b>-Edge Computing and IoT</b> - The Latency Disadvantage of Cloud, Low Latency Needs, Extending Edge to A Fog Hierarchy, Multi-level Caching, Edge computing and IIoT, Communication of IIoT, Decentralization. [10 hr.s]</p> |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### Learning and Teaching Strategies

استراتيجيات التعلم والتعليم

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Strategies</b> | <p>The main strategy that will be adopted in delivering this module focuses on fostering active student engagement during exercises, fostering the development of critical thinking skills, and encouraging participation. This will be accomplished through a combination of classroom instruction, interactive tutorials, and the inclusion of engaging experiments that involve sampling activities that capture students' interest. The aim is to refine and enhance students' critical thinking abilities while ensuring their active involvement in the learning process.</p> |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### Student Workload (SWL)

الحمل الدراسي للطلاب

|                                                                                |     |                                                                            |     |
|--------------------------------------------------------------------------------|-----|----------------------------------------------------------------------------|-----|
| <b>Structured SWL (h/sem)</b><br>الحمل الدراسي المنتظم للطلاب خلال الفصل       | 74  | <b>Structured SWL (h/w)</b><br>الحمل الدراسي المنتظم للطلاب أسبوعياً       | 5.2 |
| <b>Unstructured SWL (h/sem)</b><br>الحمل الدراسي غير المنتظم للطلاب خلال الفصل | 76  | <b>Unstructured SWL (h/w)</b><br>الحمل الدراسي غير المنتظم للطلاب أسبوعياً | 5.4 |
| <b>Total SWL (h/sem)</b><br>الحمل الدراسي الكلي للطلاب خلال الفصل              | 150 |                                                                            |     |

| Module Evaluation     |                 |             |                  |            |                           |
|-----------------------|-----------------|-------------|------------------|------------|---------------------------|
| تقييم المادة الدراسية |                 |             |                  |            |                           |
|                       |                 | Time/Number | Weight (Marks)   | Week Due   | Relevant Learning Outcome |
| Formative assessment  | Quizzes         | 2           | 5% (10)          | 6, 10      | LO #1,2,3,4               |
|                       | Assignments     | 2           | 5% (10)          | 8, 13      | LO # 5,6,8,9,             |
|                       | Projects / Lab. | 1           | 10% (10)         | Continuous |                           |
|                       | Report          | 1           | 10% (10)         | 14         | LO # 10, 11, 12           |
| Summative assessment  | Midterm Exam    | 2 hr        | 20% (10)         | 7          | LO # 1-6                  |
|                       | Final Exam      | 4hr         | 50% (50)         | 16         | All                       |
| Total assessment      |                 |             | 100% (100 Marks) |            |                           |

| Delivery Plan (Weekly Syllabus) |                                                                                                                                                                                                                                                   |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| المناهج الاسبوعي النظري         |                                                                                                                                                                                                                                                   |
|                                 | Material Covered                                                                                                                                                                                                                                  |
| Week 1                          | <b>The Era of Cloud Computing:</b> The Motivations for Cloud, Power wall, Racks of Server Computer, Elastic Computing, Multi-tenant Clouds, IaaS, PaaS, SaaS, and DaaS.                                                                           |
| Week 2                          | <b>Types of Clouds and its Providers:</b> Private and Public Cloud, Provider Lock-in, Hybrid Cloud, Multi-Cloud, Hyperscale.                                                                                                                      |
| Week 3                          | <b>Data Center Infrastructure and Equipment:</b> Racks, Aisles, and Pods, Power and Cooling, Network Equipment, North-South and East-West Network Traffic, Fat tree Design, leaf spine scaling, Unified Data Centers Network.                     |
| Week 4                          | <b>Virtual Machines and Containers:</b> Approaches To virtualization, Properties of Virtualization, Level of Trust and I/O devices, VM Migration, Hypervisor. Container approach, Docker Containers, Docker software components.                  |
| Week 5                          | <b>Virtual Networks and Virtual Storage:</b> Virtual Networks, Overlay and Underlays, VLANs, VXLAN, Virtual Network Switch, NAT, Mobility, SDN, The OpenFlow Protocol, Programmable Networks. Local and Remote Storage, NAS, SAN, Object Storage. |
| Week 6                          | <b>Consensus:</b> Raft, Paxos, consistency levels, CAP, theorem.                                                                                                                                                                                  |
| Week 7                          | <b>Software :</b> Cloud native vs. Conventional Software, Parallel Processing, MapReduce Programming Paradigm, Math of MapReduce, Apache Hadoop, HDFS, Hadoop support for Programming languages.                                                  |
| Week 8                          | <b>Microservices:</b> Monolithic Apps in Data Centers, The Microservices Approach: Pros and Cons, Microservices Granularity, Communication Protocols for Microservices, Service Mesh Proxy, Microservices Technologies.                           |
| Week 9                          | Mid-term-1                                                                                                                                                                                                                                        |

|                |                                                                                                                                                                                                                                                                                                  |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Week 10</b> | <b>Cloud Storage:</b> File, Object, Database storage systems, Software Defined Storage                                                                                                                                                                                                           |
| <b>Week 11</b> | <b>Serverless Computing and DevOps:</b> The serverless Computing Approach, Stateless Servers and Containers, Serverless Infrastructure, An Example of Serversles Processing. DevOps Approach, Continuous Integration, Continuous Delivery, Caucious Deployment, Sandbox, Canary, and Blue/Green. |
| <b>Week 12</b> | <b>Edge Computing and IoT:</b> The Latency Disadvantage of Cloud, Low Latency Needs, Extending Edge to A Fog Hierarchy, Multi-level Caching, Edge computing and IIoT, Communication of IIoT, Decentralization.                                                                                   |
| <b>Week 13</b> | <b>Cloud Security and Privacy:</b> Cloud Security Problems, Traditional Security Methods and its insufficiency with cloud, Zero Trust Security Model, Identity Management, PAM, AI and Security, Protecting Remote Access, Privacy in Cloud, Back Doors, Side Channels.                          |
| <b>Week 14</b> | <b>Building Your Own Cloud:</b> Case Study, see TextBook#2                                                                                                                                                                                                                                       |
| <b>Week 15</b> | <b>Building Your Own SaaS:</b> Case Study, see TextBook#2                                                                                                                                                                                                                                        |
| <b>Week 16</b> | <b>Preparatory week before the final Exam</b>                                                                                                                                                                                                                                                    |

| <b>Delivery Plan (Weekly Lab. Syllabus)</b><br>المنهاج الأسبوعي للمختبر |                                                          |
|-------------------------------------------------------------------------|----------------------------------------------------------|
|                                                                         | <b>Material Covered</b>                                  |
| <b>Week 1</b>                                                           | Lab 1: hosting providers portal mgmt.                    |
| <b>Week 2</b>                                                           | Lab 2: hosting specs and pricing                         |
| <b>Week 3</b>                                                           | Lab 3: virtualization software (installation, config)    |
| <b>Week 4</b>                                                           | Lab 4-5: VM mgmt.                                        |
| <b>Week 5</b>                                                           |                                                          |
| <b>Week 6</b>                                                           | Lab 6: backup, recovery, scaling, up down.               |
| <b>Week 7</b>                                                           | Lab 7-8: Proxmox mgmt                                    |
| <b>Week 8</b>                                                           |                                                          |
| <b>Week 9</b>                                                           | Lab 9: migration offline, online, hypervisor replacement |
| <b>Week 10</b>                                                          | Lab 10-11-12: docker mgmt                                |
| <b>Week 11</b>                                                          |                                                          |
| <b>Week 12</b>                                                          |                                                          |
| <b>Week 13</b>                                                          | Mgmt. tools                                              |
| <b>Week 14 &amp; 15</b>                                                 | Virtual appliances                                       |

### Learning and Teaching Resources

مصادر التعلم والتدريس

|                   | Text                                                                                                                                                                                                                                                                   | Available in the Library? |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| Required Texts    | <b>Textbooks</b><br><b>Book#1:</b> Douglas E. Comer, The Cloud Computing Book, The future of Computing Explained, 1st Edition, CRC Press, 2021.<br><b>Book#2:</b> Ian Foster and Dennis B. Gannon, "Cloud Computing for Science and Engineering", The MIT Press, 2017. | Yes                       |
| Recommended Texts |                                                                                                                                                                                                                                                                        | No                        |

### Grading Scheme

مخطط الدرجات

| Group                               | Grade                   | التقدير             | Marks (%) | Definition                            |
|-------------------------------------|-------------------------|---------------------|-----------|---------------------------------------|
| <b>Success Group<br/>(50 - 100)</b> | <b>A - Excellent</b>    | امتياز              | 90 - 100  | Outstanding Performance               |
|                                     | <b>B - Very Good</b>    | جيد جدا             | 80 - 89   | Above average with some errors        |
|                                     | <b>C - Good</b>         | جيد                 | 70 - 79   | Sound work with notable errors        |
|                                     | <b>D - Satisfactory</b> | متوسط               | 60 - 69   | Fair but with major shortcomings      |
|                                     | <b>E - Sufficient</b>   | مقبول               | 50 - 59   | Work meets minimum criteria           |
| <b>Fail Group<br/>(0 – 49)</b>      | <b>FX – Fail</b>        | راسب (قيد المعالجة) | (45-49)   | More work required but credit awarded |
|                                     | <b>F – Fail</b>         | راسب                | (0-44)    | Considerable amount of work required  |
|                                     |                         |                     |           |                                       |

**Note:** Marks Decimal places above or below 0.5 will be rounded to the higher or lower full mark (for example a mark of 54.5 will be rounded to 55, whereas a mark of 54.4 will be rounded to 54. The University has a policy NOT to condone "near-pass fails" so the only adjustment to marks awarded by the original marker(s) will be the automatic rounding outlined above.