Table 1: The Knowledge Area, Algorithmic Foundations mapped against sections covered in selected OERs

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | **Khan Academy Computer Science Theory** | **MIT OCW Introduction to algorithms** | **MIT OCW Theory of Computation** | [**MIT OCW Introduction To Algorithms (SMA 5503)**](https://ocw.mit.edu/courses/6-046j-introduction-to-algorithms-sma-5503-fall-2005/) | **Harvard Introduction to Computer Science (edX)** | **HackerEarth data structures/ Algorithms/**  **Basic Programming** | **Standford Algorithms Specialisation (via Coursera)** | **OpenDSA Data structures and algorithms module collection** |
| **AL-Foundational** | CS Core | Abstract Data Type and operations | X | X |  |  | X | X |  | X |
| Arrays |  | X |  | X | X | X |  | X |
| Records/Structs/Tuples and Objects |  |  |  |  | X |  |  | X |
| Linked lists |  | X |  | X | X | X |  | X |
| Stacks |  |  |  |  | X | X |  | X |
| Queues and deques |  | X |  |  | X | X |  | X |
| Hash tables/maps | X | X |  | X | X | X | X | X |
| Graphs (e.g., [un]directed, [a]cyclic, [un]connected, and [un]weighted) | X | X |  |  |  | X | X | X |
| Trees | X | X |  | X | X | X | X | X |
| Sets | X | X |  |  | X |  |  | X |
| Search algorithms | X | X |  | X | X | X | X | X |
| Sorting algorithms (e.g., stable, unstable) | X | X |  | X | X | X | X | X |
| Graph algorithms | X | X |  | X | X | X | X | X |
| KA Core | Sorting algorithms | X | X |  | X | X | X | X | X |
| Graph algorithms | X | X |  | X | X | X | X | X |
| Matching | X | X |  |  |  |  |  |  |
| None | Cryptography algorithms (e.g., SHA-256) | X |  |  |  | X |  |  |  |
| Parallel algorithms |  |  |  | X |  |  |  |  |
|  | Consensus algorithms (e.g., Blockchain) |  |  |  |  |  |  |  |  |
| Quantum computing algorithms |  |  |  |  |  |  |  |  |
| Fast-Fourier Transform (FFT) algorithm |  |  |  |  |  |  |  | X |
| Differential evolution algorithm |  |  |  |  |  |  |  | X |
| AL-Strategies | CS Core | Paradigms | X | X |  | X | X |  | X | X |
| Handling exponential growth (e.g., heuristic A\*, branch-and-bound, backtracking) |  | X |  | X |  | X | X | X |
| Iteration vs recursion (e.g., factorial, tree search) |  | X |  | X | X | X | X |  |
| KA Core | Paradigms |  |  |  |  |  |  | X |  |
| None | Quantum computing |  |  |  |  |  |  |  |  |
| AL-Complexity | CS Core | Complexity Analysis Framework |  | X |  | X |  | X | X | X |
| Asymptotic complexity analysis (average and worst-case bounds) |  | X |  | X |  |  | X | X |
| KA Core | Little-o, Little-Omega, and Little Theta notations | X |  |  | X |  |  |  |  |
| Formal recursive analysis |  | X |  | X |  | X |  | X |
| Amortized analysis |  |  |  | X |  |  |  | X |
| Turing Machine-based models of complexity |  |  |  |  |  |  |  |  |
| AL-Models | CS Core | Formal automata |  |  | X |  |  |  |  |  |
| Formal languages, grammars and Chomsky Hierarchy |  |  | X |  |  |  |  |  |
| Relations among formal automata, languages, and grammars |  |  | X |  |  |  |  |  |
| Decidability, (un)computability, and halting |  |  | X |  |  |  |  |  |
| The Church-Turing thesis |  |  | X |  |  |  |  |  |
| Algorithmic correctness |  |  |  |  |  |  |  |  |
| KA Core | Deterministic and nondeterministic automata |  |  | X |  |  |  |  |  |
| Pumping Lemma proofs |  |  | X |  |  |  |  |  |
| Decidability |  |  | X |  |  |  |  | X |
| Reducibility and reductions |  |  | X |  |  |  |  | X |
| Time complexity based on Turing Machine |  |  | X |  |  |  |  | X |
| Space complexity (e.g., Pspace, Savitch’s Theorem) |  |  | X |  | X |  |  | X |
| Equivalent models of algorithmic computation |  |  |  |  |  |  |  |  |
| None | Quantum computation |  |  |  |  |  |  |  |  |
| Column vector representations of qubits |  |  |  |  |  |  |  |  |
| Matrix representations of quantum operations |  |  |  |  |  |  |  |  |
| Simple quantum gates (e.g., XNOT, CNOT) | X |  |  |  |  |  |  |  |
| AL-SEP | CS Core | Social, ethical, and secure algorithms |  |  |  |  |  |  |  |  |
| Algorithmic fairness |  |  |  |  |  |  |  |  |
| Anonymity (e.g., Differential Privacy) |  |  |  |  |  |  |  |  |
| Accountability/Transparency |  |  |  |  |  |  |  |  |
| Responsible algorithms |  |  |  |  |  |  |  |  |
| Economic and other impacts of inefficient algorithms |  |  |  |  |  |  |  |  |
| Sustainability |  |  |  |  |  |  |  |  |
|  | KA Core | Context aware computing |  |  |  |  |  |  |  |  |
| **Matches** |  | **58** | **15** | **20** | **11** | **18** | **18** | **17** | **14** | **27** |

Table 2: Evaluating OERs using criteria from modified rubric from The University of Texas at Austin

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Khan Academy Computer Science Theory** | **MIT OCW Introduction to Algorithms** | **MIT OCW Theory of Computation** | [**MIT OCW Introduction To Algorithms (SMA 5503)**](https://ocw.mit.edu/courses/6-046j-introduction-to-algorithms-sma-5503-fall-2005/) | **Harvard Introduction to Computer Science (edX)** | **HackerEarth data structures/ Algorithms/**  **Basic Programming** | **Standford Algorithms Specialisation (via Coursera)** | **OpenDSA Data structures and algorithms module collection** |
| **Criteria** |  | | | | | | | |
| **Created** | 2014 | 2020 | 2020 | 2005 | 2018 | 2012 | 2020 | 2011 |
| **Usage requirements** | Need to make an account/sign up | Accessible without signing up | Accessible without signing up | Accessible without signing up | Need to create an edX account and enrol for this course | Need to sign up for the full experience, but can access tutorials without doing so | Need to create a Cousera account and enrol for this course | Accessible |
| **Breadth, perspectives and accuracy** | | | | | | | | |
| **The information in the OER is correct** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **There is appropriate coverage of material in a clear, logical manner** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **There is accurate and recent expertise in the relevant subject matter** | Accurate: Yes  Recent; No updates in the last two years | Yes, accompanying textbook last updated in 2022 | Yes | Accurate: Yes  Recent: No, lectured in 2005 | Yes | Accurate: Yes  Recent: no clear updates except for leaderboard updates | Yes | Yes |
| **There is thorough exploration of course content** | Yes, for 14/58 topics | Yes, for 18/58 topics | Yes, for 11/58 topics | Yes, for 18/58 topics | Yes, for 14/58 topics | Yes, for 18/58 topics | Yes, for 14/58 topics | Yes, for 27/58 topics |
| **The OER provides theoretical perspectives for the topic(s)** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **There are no spelling errors** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **The OER aligns with course student learning outcomes and objectives** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **There is an authoritative author involved with the OER** | Yes, Darthmouth College professors, Tom Cormen and Devin Balkcom | Yes, MIT educators Prof Erik Demaine, Dr Jason Ku and Prof Justin Solomon | Yes, MIT lecturer Prof Michael Sipser | Yes, MIT professors Prof Charles Leiserson and Prof Erik Demaine | Yes, Harvard professor Prof David Malan | Yes, the founders are Sachin Gupta (credentials at Microsoft and Google) and Vivek Prakash | Yes, the lecturer is Columbia University professor, Prof Tim Roughgarden | Virginia Tech lecturer, Cliff Shaffer is the project director |
| **Recommended by other users** | -- | Yes | -- | Yes | Yes | -- | Yes | -- |
| **Production Quality** | | | | | | | | |
| **The content in the OER is clear and understandable** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **The interface and design are easy to navigate** | Yes | Somewhat | Yes | Somewhat: the lecture notes are below the lecture videos and not clearly sectioned | Yes | Yes | Yes | Yes |
| **The OER is designed to promote learning** | Yes; discussion forums, activities and lessons included | Yes, practice problems and problem-solving video sessions | Yes, practice problems and exam questions | Yes, practice problems and tests | Yes, practice problems, tests, interactive learning | Somewhat: interactive practice problems and visualisers but no audio and video resources | Yes; there is interactive learning | Yes, interactive learning, visualisers, audio resources |
| **The sound quality is high for audio resources** | n/a | n/a | n/a | n/a | n/a | n/a | n/a | Yes |
| **The video and audio quality are high** | Yes | Yes | Yes | Average: the videos are a little dated | Yes | n/a | Yes | n/a |
| **Accessibility** | | | | | | | | |
| **Transcript provided for audio resources** | n/a | n/a | n/a | n/a | n/a | n/a | n/a | Yes |
| **Closed captions/subtitles provided for video resources** | Yes | Yes | Yes | Yes | Yes | n/a | Yes | n/a |
| **Alt tags/long descriptions are provided for graphics** | No | No | No | No | No | No | No | No |
| **The OER is accessible in multiple modes** | Yes | Yes: reading online and downloading | Yes, reading online and downloading | Yes | Yes, available in several different modes and platforms and media types | No, only available for viewing online | Yes | No, only available for online viewing |
| **Student Engagement** | | | | | | | | |
| **The OER promotes active learning/class participation/**  **collaboration** | Yes, with discussion forums | No | No | No | Yes, on several different platforms | No; there are leaderboards but there are no discussion forums | Yes, there are discussion groups | Yes, interactive learning is encouraged |
| **There is opportunity for students to test their learning** | Yes, in the form of ’Challenges’ | Yes: quizzes, practice problems etc | Yes, practice problems and exam quizzes | Yes, practice problems and quizzes | Yes, practice questions and interactive learning | Yes, it is interactive, and the code gets checked immediately | Yes, with practice and exam questions | Yes, with interactive code compilers |
| **The OER includes a mix of instructional approaches** | Yes: no audio resources, needs more video resources | Yes, but no audio resources and no interactive learning | Yes, but no audio resources | Yes, but no audio resources | Yes, but no audio resources | Yes, but there are no audio and video resources | Yes, but no audio resources | Yes, but no video resources |
| **The OER includes multiple modalities to support student learning** | Yes: graphs, images, videos | Yes: graphs, images, videos | Yes | Yes: graphs, images, videos | Yes, graphs, images, videos | Somewhat: interactive code compilers and visualisers | Yes | Yes |
| **The OER includes additional faculty resources** | Yes, after every unit | Yes, after every unit | Yes, with an accompanying textbook | Yes, in some sections | Yes | No | Yes, there is accompanying reading | Yes, there is accompanying reading |
| **The OER includes effective and engaging student assessments** | Yes | Somewhat: present but not engaging | No | Somewhat but it isn’t engaging | Yes | Yes | Yes | Yes |
| **Cultural Responsiveness** | | | | | | | | |
| **The OER provides for self-reflection and self-assessment** | No | No | No | No | No | No | Yes | Yes |
| **Licensing and adaptation** | | | | | | | | |
| **Does the license allow for modification or adaptation?** | No | Yes, under the Creative Common License | Yes, under the Creative Commons License | Yes, under the Creative Commons License | Yes, under the Creative Commons license | Unspecified | Yes, for non-commercial purposes | Yes |
| **Is the OER easily modifiable?** | No | No | No | No | No | No | Yes, there is support available for this | Yes, nut no support available for this |

Table 3: Summary of evaluating OERs according to the questions posed in ‘Approaches to curating OERs’

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Easily find-able** | **Clearly described** | **Clearly licensed (permissive license)** | **Trustworthy and valuable source** | **Easily modifiable** | **Self-contained** | **Free of copyrighted material** | **Recommended by other users** | **Imperfect but applicable to your use case** |
| **Resource** |  |  |  |  |  |  |  |  |  |
| **Khan’s Academy** | Yes | Yes | Yes | Yes | No | Yes | No | -- | Yes, 67% applicable |
| **MIT Introduction to Algorithms** | Yes | Yes | Yes | Yes | No | Yes | No | Yes | Yes, approximately 50%  applicable |
| **MIT introduction to algorithms 2005** | Yes | Yes | Yes | Yes | No | Yes | No | Yes | Yes, about 65% applicable |
| **MIT Theory of Computation** | Yes | Yes | Yes | Yes | No | Yes | No | -- | Yes, about 50% applicable |
| **Harvard Introduction to computer science** | Somewhat | Yes | Yes | Yes | No | Yes | No | Yes | Yes, 60% |
| **HackerEarth** | Yes | Yes | No | Yes | No | Yes | Yes | -- | Yes |
| **Stanford Algorithms Specialisation** | Somewhat | Yes | Yes | Yes | No | Yes | No | Yes | Yes |
| **OpenDSA Data Structures and Algorithms** | yes | Yes | No | Somewhat | No | Yes | Yes | -- | Yes |