Brochure

Matching & Selection Procedure

BSc Computer Science & Engineering

2023-2024

2

Brochure 2—Matching & Selection

Matching & Selection Procedure
This brochure explains what to expect when participating in the BSc Computer Science & Engineering (CSE) Matching & Selection procedure.

The deadline to apply for CSE at the TU Delft is **January 15**. Note that this is a fixed deadline.

If you are still considering whether this is the right study for you, please read Brochure 1 – How to choose your study from the website.

Content

- **Bachelor Computer Science & Engineering**

- **Matching & Selection Procedure in 8 steps**

  Step 1 - Register in Studielink before Jan 15
  Step 2 - Start M&S procedure
  Step 3 - Complete OSE
  Step 4 - Trial run proctoring
  Step 5 - Take the CST
  Step 6 - Complete Teamwork assignment
  Step 7 - Receive your ranking number
  Step 8 - Accept your spot

- **Taking the CST**

- **Academic integrity**

- **How to prepare for the Matching & Selection**

- **Planning**

- **How your ranking number is calculated**

- **How ranking works in Studielink**

- **More information**

- **Timeline**

- **Appendix**

All dates and time in this brochure are in Central European Time (CET), Dutch local time.

Bachelor Computer Science & Engineering

During the bachelor Computer Science and Engineering (BSc CSE) you will learn how computers, networks and embedded systems work. You will study algorithms and address questions such as: "what is an algorithm?" and "how can you represent software mathematically?" Of course, you will also study data structures and work with various programming languages. You will learn how to model complex systems and how users interact with such systems. During this programme you will solve problems in a logical and analytical way.

Who are we looking for?

- Curious problem-solvers and profound analytical engineers
- Pro-active team workers who are able to collaborate and communicate well
- Competent learners with good planning and self-regulatory skills
- Disciplined students who are capable of handling a large amount of self-study
- Students who adhere to and identify with the TU Delft values: Diversity, Integrity, Respect, Engagement, Courage and Trust (DIRECT), as embodied in the TU Delft Code of Conduct.

BSc CSE has two tracks: Bilingual (Dutch-English) track and the English track. Please check the language requirements on the Admission Requirements page to see for which track you are admissible.

Matching & Selection procedure in short

Computer Science & Engineering at TU Delft is a Numerus Clausus programme. This means that there is a maximum capacity of (550) first-year students and a Matching & Selection procedure.

During the *Matching* part of the procedure you will dive into several topics that are taught in the programme to get a better impression of studying CSE at TU Delft. The Matching activities are mandatory and need to be completed in order to receive a ranking number, but they will not influence your specific place in the ranking. In the *Selection* part, you will make a test (CST) on which your ranking number will be based. You can prepare for the selection test by studying the materials on page 8 in this brochure. You can complete the Matching & Selection procedure fully online. We also offer the opportunity to do the selection test on campus, but the Matching activities will still be online.

Upon completion of all Matching & Selection activities you will receive a ranking number that is constructed of three components (the percentages indicate the weight of the component towards your final score):

- Mathematics (30%)
- Systematic Reasoning and Logical Thinking (35%)
- Algorithmic & Computational Thinking (35%)

Language requirements

For candidates in the English track, the procedure will be entirely in English. Candidates in the Bilingual track will do parts of the CST in Dutch. The rest of the procedure will be in English and is the same for both tracks.

Regulations

All rules governing the Matching & Selection procedure can be found in the Regulation Matching & Selection Criteria and Procedure, which can be downloaded from the website.

Matching & Selection procedure in 8 steps

Step 1 - Register in Studielink before January 15

In order to apply and participate in the Matching & Selection procedure, you need to register for the CSE programme online in [Studielink](#), the Dutch national enrolment system for higher education.

In Studielink you will be asked which track you want to follow. VWO students and applicants who fulfill the Dutch language requirements can enroll in the Bilingual (Dutch-English) track. International students who fulfill the English language requirements can enroll in the English track. More information about the admission and language requirements can be found on the [Admission Requirements page](#).

Please note that it takes time to obtain a login for Studielink, to collect the required documents and to complete your application. If you have an international secondary school diploma, make sure to continue your application in the online application system of TU Delft, called Osiris and submit your [complete application](#) file by **15 January.** These deadlines are fixed, as we need to comply with strict national deadlines set by the Dutch government. More information about the exact application procedure can be found on the [website](#).

Email

Please ensure that the email address you use in the Matching & Selection procedure is the same as the email address that you used to register in Studielink, as this will your unique identifier throughout the procedure. Keep in mind that you will be kept informed through email on a regular basis about the next steps in the procedure. You need access to the Studielink email address until the beginning of the study year (September 2023).

Step 2 - Start Matching & Selection procedure

After the Studielink registration deadline has passed (15 Jan), the first communication regarding the Matching & Selection procedure will be by email, which you will receive on your Studielink email address and before **21 January.**

In this first email you will be asked to do the following:

- Fill in the 'Studying at the TU Delft' survey

- Choose a slot for the CST*

- Choose a slot for the Teamwork Assignment*

- Create an account on the Online Courses platform

- Start with the OSE

These steps are part of the Matching and will *not* be used to calculate your ranking number, but you have to complete them in order to continue with the Matching & Selection procedure.

** If you have completed the OSE you will receive the confirmation of your CST date and Teamwork timeslot after the OSE deadline and **before 8 February**. There is a fixed amount of places per CST date and Teamwork timeslot. If the amount of candidates exceeds the available seats for a specific moment, you may be assigned one of your other slot choices. Keep in mind that you are responsible to ensure a well functioning internet connection that allows for [proctoring](#) if you take the CST online. For the Teamwork Assignment only a stable internet connection is needed.*

Step 3 - Complete Online Student Experience (OSE)

The OSE is part of the Matching procedure and is meant to help you gain a better impression of the CSE bachelor programme. You will be introduced to several algorithms and learn how to implement them in different languages. You need to complete the OSE before **31 January 23:59 CET.** Although the OSE will *not* be used to calculate your ranking number, completing the OSE will grant you access to the CST, so make sure to answer all questions in a meaningful way.

Step 4 - Trial Run Proctoring

From **13 - 16 February** you will have the opportunity to test if the proctoring software works on your computer. Please keep in mind that you are responsible yourself for assuring good working equipment and a well-functioning internet connection that allows for proctoring if you are taking the CST online (see page 6 for the proctoring specifications). It is recommended that candidates who are taking the CST on campus also take part in the trial run, as you will get to see and work with the platform on which you will also make the CST.

Step 5 - Take the Cognitive Skills Test (CST)

The **CST** can be completed **on campus on Saturday 18 February** (time to be determined) **or online on 20, 22, or 23 February between 10:00-23:59 CET.** You will take the CST on the date confirmed to you. The score on each of the three components will count for 100% towards the final ranking number. More information about the CST can be found on the next pages of this brochure.

Step 6 - Complete the Teamwork assignment

For the last step of the procedure you will be assigned to a team. You will come together online with your team during a chosen timeslot to participate in a team challenge. From **2 March** onwards the Teamwork Assignment will be open so you have a few days to meet your team. After the challenge you will need to hand in a reflection before **13 March 23:59 CET.** Although the Teamwork Assignment will not be used to calculate your ranking number, you need to complete the Teamwork Assignment in a meaningful way in order to receive a ranking number.

Step 7 - Receive your ranking number

You will receive your **ranking number** in **Studielink** on **15 April.** If your ranking number is within our fixed capacity, you will automatically receive a (conditional*) offer for the academic year 2023-2024. If your ranking number is higher, it is possible to receive an offer at a later point in time, as not all candidates will accept their spot.

Step 8 - Accept your spot

Make sure to check your email regularly as you need to accept a spot within 2 weeks in Studielink. Remember to finalize your registration and upload all required documents.

*Admission requirements

Please note that participating in the Matching & Selection procedure or receiving a ranking number, does not automatically mean that you meet the admission requirements, as this constitutes a separate process.

Taking the Cognitive Skills Tests (CST)

The Cognitive Skills Tests (CST) contains the following three tests:

- Mathematics (30%)
- Systematic Reasoning & Logical Thinking (35%)
- Algorithmic & Computational Thinking (35%)

The percentages between brackets indicate the relative weight used to calculate your final grade. The complete CST will take a maximum of 3 hours to complete. Each of the three tests takes one hour to complete. Per test a counter will stay visible showing the remaining time. Once you start the first test, you have to complete all three tests in *one* session. The test can only be taken in the set order as shown above. You cannot re-sit or re-take the CST.

Extra time

Candidates who have been diagnosed with a learning disability and/or are experiencing extenuating circumstances can request extra time for the CST by sending an email to selection-bsc-cse@tudelft.nl. Requests need to be supported with official documentation (e.g. a medical or psychological statement), which is readable in English or Dutch and should be submitted before **5 February 23:59 CET**, stating your full name and student number.

Language requirements

For candidates in the English track, the procedure will be entirely in English. Candidates in the Bilingual track will do parts of the CST in Dutch. The rest of the procedure will be in English and is the same for both tracks.

On campus

Candidates will be offered the opportunity to make the CST on campus on **Saturday 18 February.** The exam will not be proctored when making the CST on campus. If the amount of candidates exceeds the available seats for the campus CST day, seats will be randomly allocated among the candidates. Candidates who did not get a seat will be assigned to one of their other chosen (online) slots.

Proctoring

To ensure a honest selection procedure all candidates who take the CST online will be remotely proctored, which means that candidates are "followed" online to check whether the test is completed under the correct conditions. You and your computer screen will be monitored during the CST to ensure that you comply with the academic integrity standards of the TU Delft. TU Delft cannot guarantee that proctoring will work in all countries, as some countries have strict regulations and firewalls, which may mean that you require a VPN connection. **You are responsible yourself to ensure you are able to take the CST online.**

Proctoring requirements

When you take the CST online, make sure to check in advance whether you meet the requirements as set by our proctor:

Hardware Requirements

- Working web camera (using your phone as webcam is not allowed)
- Your computer needs to have a microphone (headsets or ear pods used as microphone is not allowed).
- You are only allowed to have one screen.
- You cannot use tablets, hybrid devices, mobile devices, Chrome Casts, Linux Machines and Chrome Books.

Operating System Requirements

- You can only use Windows or Mac operating systems.

Connectivity Requirements

You need to have stable internet connection. Maintaining a minimum connection speed of 500kbps is required during proctoring. We recommend using a cable connection as opposed to WiFi.

Academic integrity

It is important that you have a good environment to take the CST. Make sure that your phone is completely switched off and out of sight. Let the people around you know that you are taking the CST so they do not disturb you (which could be seen as fraud) or make a lot of noise which could distract you during the test.

All candidates taking the CST need to comply with the academic integrity standards of the TU Delft. You will need to take the tests individually and without other sources of information. It is *not* allowed to share questions or answers of the CST with third parties. Any (attempted) act or omission thereof that may result in making it more difficult or impossible to form an objective assessment constitutes fraud. The Selection Committee can impose sanctions on fraud, like awarding zero points or excluding a candidate from the procedure.

What is *not* allowed during the CST

- Use of documentation other than the documentation permitted for the test is <u>not</u> allowed.
- A calculator is <u>not</u> allowed, nor is a calculator on an other device
- Use of a second computer is <u>not</u> allowed
- Use of a (smart) phone is <u>not</u> allowed
- Use of any other mobile device than the device on which the test is taken is <u>not</u> allowed
- Headphones or earplugs are <u>not</u> allowed (even if they are only noise cancelling)
- It is <u>not</u> allowed to have someone else in the room in which the test is taken nor is it allowed to have a radio or television playing in the background.

How to prepare for the Matching & Selection: *Matching*

The Matching part of the procedure consists of the starting surveys, Online Student Experience and the Teamwork Assignment. Although these activities are *not* graded, you have to pass them in order to receive a ranking number. You can prepare for the Matching by allocating time in your agenda for these activities. The planning on the next page shows an indication of how much time each step will cost.

How to prepare for the Matching & Selection: *Selection (CST)*

For the *selection* part of the procedure you will complete the Cognitive Skills Test (CST). On the CST you will be tested on 3 selection criteria: Mathematics, Systematic Reasoning & Logical Thinking and Algorithmic & Computational Thinking. Some elements you can prepare for and some elements not. You can find the specifics for each element below:

Mathematics

You can prepare for this element by following the free **online pre-university calculus course** (select the audit track) and by reading the **syllabus** and **formula sheet**, which can be found in the appendix of this brochure. The syllabus will give you a better insight into what is expected from you in this test. You should be able to apply techniques and formulas from memory, except for the formulas on the formula sheet, which will be available online during the test. Please remember that you will need to do all calculations by yourself as a calculator is <u>not</u> allowed.

Systematic Reasoning & Logical Thinking

You can prepare for this element by studying chapter 2 of the textbook Delftse Foundations of Computation. You can skip all the sections starred (*) in the contents of the book, as explained in chapter 1. This book can be downloaded for free from the TU Delft Open Textbook repository. At TU Delft we train our students to become analytical engineers and curious problem-solvers. Although you will find exercises in the book, you will <u>not</u> find any official answers, nor do we provide any more than those already included in the book.

> S. Hugtenburg & N. Yorke-Smith (2018) *Delftse Foundations of Computation.*
> Retrieved from https://textbooks.open.tudelft.nl/index.php/textbooks/

Algorithmic & Computational Thinking

In the last part of the CST we will test your potential to solve puzzles, process-oriented thinking skills and your ability to come up with efficient solutions to real-world computational problems. You *cannot* prepare for the Algorithmic & Computational Thinking as this is an aptitude test.

Planning

Below you can see an indication of how much time each step of the Matching & Selection procedure will cost. The time you spend on (preparing for) the procedure may differ per person depending on pre-knowledge. See also the timeline in the appendix of this brochure.

Preparing for the CST—8 hours (minimum)

Reading all the communication by the M&S Team carefully (2-3 hours)

Step 1 — Submitting complete application before registration deadline **15 January** (1-2 hours)

Step 2 — Start Matching & Selection procedure **20-24 January** (1-2 hours)

Step 3 — OSE **20-31 January** (3-4 hours)

Step 4 — Testing proctoring software **13—16 February** (1 hour)

Step 5 — CST on the **18 (campus) or 20, 22, 23 February (online)** (3-4 hours)

Step 6 — Teamwork assignment **2-13 March** (2-3 hours)

Total: approximately 25 hours

How your ranking number is calculated

All candidates have to complete all steps in the Matching & Selection procedure in order to obtain a ranking number. Your ranking number will be based on the CST score:

- Mathematics (30%)
- Systematic Reasoning and Logical Thinking (35%)
- Algorithmic & Computational Thinking (35%)

The ranking numbers are computed in accordance with a strict protocol. This process is overseen by the CSE Selection Committee. For each track, the scores of the three tests will be converted to z-scores and combined into your final z-score. The tracks will be combined alternately into one final ranking list.

A z-score or standard score, is a relative score, as it compares how you did on the tests in relation to the performance of the other candidates within your track. As a result there is no fixed pass or fail grade. Higher tests scores will result in better (=lower) ranking numbers. The candidate with the highest final score will thus receive the lowest ranking number, the candidate with the second highest score will receive the next ranking number, and so on. As educational systems differ per country, as well as ways to calculate average grades, your high school grades are *not* taken into account when calculating your ranking number. Please note however that a (strong) correlation between your high school grades and your performance on the tests is likely.

How ranking works in Studielink

On **15 April** Studielink will announce your ranking number. Due to reasons of confidentiality and objectivity we will *not* communicate about the method and evaluation of the criteria, *nor* is it possible to review the tests or individual answers given.

Please note that assigning spots is an automated process in Studielink. If your ranking number is within our maximum capacity, you will automatically receive an (conditional) offer. You will have two weeks to accept this offer in Studielink. If you do *not* accept *or* respond within two weeks, this spot will automatically be re-assigned to the next registered candidate on the ranking list who hasn't received an offer yet. If your ranking number is higher than the available capacity, you will have to wait until one of the other applicants declines their offer or opt for one of your alternative study choices. Please keep in mind that after **15 April,** applicants with ranking numbers above our maximum capacity can still be offered a spot, so make sure to check your email and Studielink on a weekly basis, as this process continues throughout summer.

More information

- Admission & Application
- BSc CSE Matching & Selection
- FAQ
- selection-bsc-cse@tudelft.nl

Timeline procedure
Application and Matching & Selection BSc CSE 2023/2024

1. Application

    A. Apply in Studielink
    B. Choose your CSE language track
    C. Activate your TUD Net ID
    D. Continue in Osiris

STUDIELINK

Apply
1st Oct - 15th Jan 23:59 CET

2. Motivation Questionnaire
Including indication selection test (CST) preference date and Teamwork timeslot

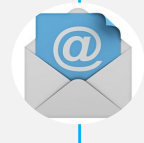**Matching, CST date & Teamwork slot**
20th Jan – 24th Jan 23:59 CET

3. Complete Online Student Experience (OSE)

Online Student Experience
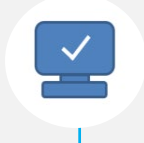**20th Jan – 31st Jan 23:59 CET**

4. Confirmation CST date
Receive the confirmation of your selection test (CST) date.

Receive CST Date Confirmation
Before 8th Feb

5. Trial Run Proctoring
Test the proctoring software on the computer you will use to take the CST.

Trial Run Proctoring
13th Feb – 16th Feb 23:59 CET

6. Take the selection test (CST)
Complete the three parts of the CST, proctored and on your own computer or take the CST on campus.

Take CST
20th Feb / 22nd Feb / 23rd Feb (proctored)
18th Feb (on campus)

7. Complete Teamwork Assignment
Complete the Teamwork Assignment (TwA) digitally and with your assigned team.

Teamwork Assignment
2rd Mar – 13th Mar 23:59 CET

8. Ranking
Studielink informs student of rank#

Receive ranking #
starting 15th April

9. Accept & Finalize
    A. Accept your spot within 2 weeks
    B. Finalize registration in Studielink

Accept spot within 2 weeks

Start in time, all deadlines are fixed!

TUDelft

Appendix

Syllabus 2a Mathematics Test

Below the minimum of expected knowledge for mathematics is presented. Note that the questions on the respective test might consist of a combination of multiple topics. The content in this syllabus is based on the material covered in Dutch VWO (i.e. pre-university education) schools.

The standard mathematical terms are written in **boldface**. Note that these terms might be very different in your native language. It is advised to check those terms carefully, look up the terms that you do not recognize and make a list of translations to your native language.

Mathematics

The math problems can and have to be solved exactly, i.e. without using approximation techniques or a calculator. Moreover, unless stated otherwise, this also implies that you should not round your answers (e.g. 0.33 is not considered the same as 1/3).

1. Functions and Graphs

    i The candidate is able to recognize and construct **compositions** of standard **functions**. Standard functions include.

    - **polynomial functions**,
    - n-**root functions** ($\sqrt[n]{x}$, $x^{\frac{1}{n}}$),
    - **power functions** (x^a, a fixed),
    - **exponential functions** (a^x, a fixed. Specifically e^x),
    - **logarithms** ($\log_a(x)$, a fixed. Specifically the **natural logarithm** $\ln(x)$),
    - **trigonometric functions** ($\sin(x)$, $\cos(x)$ and $\tan(x)$),
    - the **absolute value function** ($|x|$).

    ii The candidate is able to analyze, and transform (compositions of) these standard functions, to determine **limits**, **domain**, **range**, **asymptotes** and **symmetry**-points or -lines and to draw and recognize graphs of (compositions of) these functions.

    iii The candidate understands the concept of **inverse functions**, and can find the inverse of (compositions of) standard functions.

2. Algebraic manipulations an solving equations

    i The candidate can rewrite expressions to isolate a variable and can substitute expressions into a given function.

    ii The candidate is able to rewrite expressions into simplified form and use this skill to manipulate and solve **equations** and **inequalities** of the form $f(x) = g(x)$, $f(x) \leq g(x)$, $f(x) \geq g(x)$, $f(x) < g(x)$, $f(x) > g(x)$ and $f(x) \neq g(x)$, where f and g are (compositions of) standard functions (see 1i)

iii The candidate is able to find **roots of a function** ($f(x) = 0$) using **factorization techniques**. The candidate is able to use the **quadratic formula** to find roots of **quadratic polynomials** ($ax^2 + bx + c = 0$).

iv The candidate can solve **systems of linear equations**, $\begin{cases} ax + by = c, \\ dx + ey = f, \end{cases}$

with a, b, c, d, e, f constants.

3. Differential Calculus

i The candidate knows the **derivatives** of standard functions, and is able to apply the **sum rule**, **product rule**, **quotient rule**, and **chain rule** to determine derivatives of functions composed of standard functions.

ii The candidate is able to determine the first derivative ($f'(x), \frac{dy}{dx}, \frac{d}{dx}f(x)$) and second derivative ($f''(x), \frac{d^2y}{dx^2}, \frac{d^2}{dx^2}f(x)$) of functions and to use these to determine **locally increasing** and **locally decreasing** behavior, **extremal values**, and **inflection points**.

iii The candidate is able to apply differentiation to determine the **slope of a graph** and the local **tangent lines** and **normal lines** to the graph of a function, to construct and solve a optimization problems, and to solve problems concerning **distance**, **velocity** and **acceleration**.

4. Integral Calculus

i The candidate understands the concept of **integration** and related terms (including **limits of integration**, **definite/indefinite integrals** and the **integration constant**).

ii The candidate is able to determine **antiderivatives** (also called **primitive functions**) of standard functions, and is able to use this to calculate definite and indefinite integrals of functions of the form $cf(ax + b) + d$, with a, b, c, d constants and f a standard function.

iii The candidate is able to apply integration to determine **surface area** and **volume** of a **solid of revolution** and the **mean value** of a function.

5. Trigonometry

i The candidate understands the trigonometric functions $\sin(x)$, $\cos(x)$ and $\tan(x)$ and their relation to the **unit circle**. The candidate understands the terms **amplitude**, **phase**, **period**, and **frequency** and can relate those to the parameters in a **sinusoidal function** such as $f(t) = d + a\sin(b(t - c))$. The candidate is able to convert **degrees** to **radians** and vice-versa.

ii The candidate knows the exact values of $\sin(\theta)$, $\cos(\theta)$ and $\tan(\theta)$ for the following angles (in radians) $\theta = 0, \frac{1}{6}\pi, \frac{1}{4}\pi, \frac{1}{3}\pi$ or $\frac{1}{2}\pi$, as well as **integer** multiples of these angles.

iii The candidate knows is able to use periodicity and symmetry properties of $\sin(\theta)$, $\cos(\theta)$ and $\tan(\theta)$.

iv The candidate is able to find all solutions of equations $\sin(x) = c$, $\cos(x) = c$ and $\tan(x) = c$, and of $\sin(f(x)) = \sin(g(x))$, $\cos(f(x)) = \cos(g(x))$ and $\tan(f(x)) = \tan(g(x))$, where c is a constant and $f(x)$ and $g(x)$ are **linear functions** of x.

v The candidate is able to find all solutions of equations $\sin(x) = c$, $\cos(x) = c$ and $\tan(x) = c$, and of $\sin(f(x)) = \sin(g(x))$, $\cos(f(x)) = \cos(g(x))$ and $\tan(f(x)) = \tan(g(x))$, where c is a constant and $f(x)$ and $g(x)$ are linear functions of x.

vi The candidate is able to solve inequalities $\sin(f(x)) \leq c$, $\cos(f(x)) \leq c$ and $\tan(f(x)) \leq c$, where c is a constant and $f(x)$ and $g(x)$ are linear functions of x. The same for $\leq$ replaced with $<$, $>$ or $\geq$.

vii The candidate is able to apply the **Pythagorean identity** $\sin^2(x) + \cos^2(x) = 1$, **sum and difference identities** and **double angle formulae**.

6. Geometry

i The candidate is able to determine the **surface area** and **perimeter length** of two-dimensional shapes including **triangles**, **rectangles**, **circles**, etc. The candidate is able to determine the volume and surface area of three-dimensional objects including **cubes**, **pyramids**, **cylinders**, **cones**, etc.

ii The candidate can use properties of lines, triangles, circles, and **quadrilaterals** to determine **lengths** and **angles**. The candidate knows and can use the properties of a **right-triangle**, **isosceles triangle**, and **equilateral triangle**.

iii The candidate can use the **Pythagorean theorem**, relations between sin, cos and tan, the **law of sines** and the **law of cosines** to determine lengths and angles in triangles.

iv The candidate can formulate equations for lines and circles, and knows the relations between the slopes of normal and tangent lines.

v The candidate is able to find the **points of intersection** between lines and circles.

7. Vectors

i The candidate understands the concept of a **vector**, and can determine the **norm** (i.e. length) and **direction** of a vector.

ii The candidate can **decompose** vectors into **components**, can multiply a vector with a **scalar**, and can add and subtract vectors. The candidate can calculate the **dot product** of two vectors, and can use it for the calculation of angles and distances and to detect **orthogonality**.

iii The candidate can calculate **speed**, velocity and acceleration of a moving point whose path is described by a time-dependent vector representation.

Remark:

Vectors will be denoted boldface or with an arrow: $\mathbf{v}$ or $\vec{v}$. When expressed in components, a vector will denoted using round brackets, e.g. $\begin{pmatrix} 3 \\ -5 \end{pmatrix}$. The norm ($=$ length) of a vector $\mathbf{v}$ will be denoted as $\|\mathbf{v}\|$.

Formula sheet: Mathematics - v2019.1

Trigonometry

Pythagorean identity

$$\cos^2(x) + \sin^2(x) = 1 \tag{1}$$

Angle sum and difference identities

$$\cos(\alpha - \beta) = \cos(\alpha)\cos(\beta) + \sin(\alpha)\sin(\beta) \tag{2}$$

$$\cos(\alpha + \beta) = \cos(\alpha)\cos(\beta) - \sin(\alpha)\sin(\beta) \tag{3}$$

$$\sin(\alpha - \beta) = \sin(\alpha)\cos(\beta) - \cos(\alpha)\sin(\beta) \tag{4}$$

$$\sin(\alpha + \beta) = \sin(\alpha)\cos(\beta) + \cos(\alpha)\sin(\beta) \tag{5}$$

$$\tan(\alpha - \beta) = \frac{\tan(\alpha) - \tan(\beta)}{1 + \tan(\alpha)\tan(\beta)} \tag{6}$$

$$\tan(\alpha + \beta) = \frac{\tan(\alpha) + \tan(\beta)}{1 - \tan(\alpha)\tan(\beta)} \tag{7}$$

Double-angle formulae

$$\cos(2x) = \cos^2(x) - \sin^2(x) \tag{8}$$
$$= 2\cos^2(x) - 1 \tag{9}$$
$$= 1 - 2\sin^2(x) \tag{10}$$

$$\sin(2x) = 2\sin(x)\cos(x) \tag{11}$$

$$\tan(2x) = \frac{2\tan(x)}{1 - \tan^2(x)} \tag{12}$$

Integrals

$$\int x^a \ \mathrm{d}x = \frac{x^{a+1}}{a+1} + C \qquad (a \neq -1) \tag{13}$$

$$\int a^x \ \mathrm{d}x = \frac{a^x}{\ln(a)} + C \qquad (a \neq 1) \tag{14}$$

$$\int \frac{1}{x} \ \mathrm{d}x = \ln|x| + C \tag{15}$$

$$\int e^x \ \mathrm{d}x = e^x + C \tag{16}$$

$$\int \ln(x) \ \mathrm{d}x = x\ln(x) - x + C \tag{17}$$

$$\int \log_a(x) \ \mathrm{d}x = \frac{1}{\ln(a)}(x\ln(x) - x) + C \qquad (a > 0 \ \text{and} \ a \neq 1) \tag{18}$$

$$\int \sin(x) \ \mathrm{d}x = -\cos(x) + C \tag{19}$$

$$\int \cos(x) \ \mathrm{d}x = \sin(x) + C \tag{20}$$