

# Brochure

Matching & Selection Procedure

BSc Computer Science & Engineering

2025-2026



## Brochure 2 - Matching & Selection CSE

### 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 curious when you should choose to study CSE at the TU Delft, please read *Brochure 1 – ‘When to choose for BSc CSE’* to be found on the [Selection website](#).

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## 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. More information on studying CSE at the TU Delft can be found in [“Brochure 1 - When to study CSE”](#).

### 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](#).



### (Language) Tracks

TU Delft offers two tracks for the Bachelor Computer Science and Engineering: the *English track* and the *Bilingual track (Dutch-English)*. The English track is fully taught in English. To enrol in the Bilingual track Students have to be proficient in Dutch *and* English. Students with a foreign diploma are only admissible for the English track, unless they can show a [Dutch language proficiency certificate](#)\*. You can find more information about the overall language requirements [here](#).

## Matching & Selection procedure in short

Computer Science & Engineering at TU Delft is a Numerus Clausus programme. The programme has a maximum capacity of 550 first-year students. Because more people apply, there is a Matching & Selection (M&S) procedure. You can only participate in the Matching & Selection procedure if you have successfully applied in Studielink before 15 January. After completing all the matching and selection elements of the procedure you will receive a ranking number based on your performance in the procedure, which will determine your chance of receiving a seat for Computer Science and Engineering.

### Matching part

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 place in the ranking.

\* See page 68 of the linked document for specifics on Dutch language proficiency certificates.



## Selection Part

In the *Selection* part, you will complete a selection test (called the CST, a.k.a. Cognitive Skills Test) on which your ranking number will be based. If you aspire to perform well in the selection test, we strongly recommend that you prepare yourself. You can prepare for the selection test by studying the materials on **page 9** in this brochure. You can start preparing for the CST even before the Matching & Selection procedure begins.

It is possible to fully complete the Matching & Selection procedure online. We also offer the opportunity to take the selection test on campus and/or attend the preparation lecture at TU Delft, but all other activities will be online for everyone.

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 (40%)
- Systematic Reasoning and Logical Thinking (35%)
- Problem Solving (25%)

## 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 10 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 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.

## Admissions Office & Contact Centre

Checking whether you meet the admission requirements, such as a suitable diploma and payment details, is done by the TU Delft Admissions Office and is a process that continues from your initial application until the start of the academic year. Please keep an eye on the status of your application as you may need to submit additional documentation. For questions regarding your **application** you can send an email to the contact centre at: [contactcentre-esa@tudelft.nl](mailto:contactcentre-esa@tudelft.nl).

## Email

Please note that the email address you use in Studielink, will also be the email address that is used for the Matching & Selection procedure. This email address will be your unique identifier throughout the whole 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 2025).

### 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 by **21 January latest**. In this first email you will be asked to do the following:

- Complete the 'Studying at the TU Delft' survey (Deadline **Monday 27 January 23:59 CET**)
- Choose a preferred slot for the CST (selection test)
- Choose a preferred slot for the Teamwork Assignment
- Create an account on the Matching platform
- Start with the OSE (Online Student Experience)

These steps are part of the Matching procedure 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. To insure you do not miss any Matching & Selection emails, **green list:** [selection-bsc-cse@tudelft.nl](mailto:selection-bsc-cse@tudelft.nl) and check your spam.

### Step 3 Online Student Experience (OSE)

The OSE is one of the Matching elements and is meant to help you gain a better impression of the CSE bachelor programme. You will be introduced to a practical problem and apply computer science techniques to that domain. You need to complete the OSE before **Monday 3 February 23:59 CET**. Although the OSE will *not* be used to calculate your ranking number, you need to complete the OSE to be allowed to take the CST (selection test). So make sure to answer all questions of the OSE in a meaningful way.

### Step 4 CST preparation lecture

In the week of 3 February (date and time to be announced) you can attend a lecture in which a Mathematics lecturer and Reasoning & Logic lecturer will go through some exercises to help you with preparing for the CST. You can follow the lecture via a livestream or attend on campus. You will receive the preparation materials and location of the lecture in advance. Following the lecture is not mandatory.

### Step 5 Confirmation CST date & Teamwork timeslot

If you have completed the OSE you will receive the **confirmation** of your CST date and Teamwork timeslot after the OSE deadline and **before 12 February**. There is a fixed number of places per CST date and Teamwork timeslot. If the number of candidates exceeds the available seats for a specific slot, you may be assigned one of your other slot choices. Keep in mind that you are responsible to ensure a good test taking environment and 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 6 Trial Run Proctoring & Selection platform

From **Wednesday 12 - Monday 17 February 23:59 CET** 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 (selection test) online (see page 8 for the proctoring specifications). It is recommended that **all candidates** (also if you take the CST on campus) take part in the trial run, as you will have the opportunity to get familiar with the selection platform, on which you will complete the CST.

## Step 7 Take the Cognitive Skills Test (CST)

The **CST** (selection test) can be completed **online** on Thursday 27 February or Wednesday 5 March between 10:00-23:59 CET, or **on campus** on Saturday 8 March 11:00-14:00 CET. You will take the CST on the date confirmed to you. More information about the CST can be found on the next pages of this brochure.



## Step 8 Complete the Teamwork Assignment (TWA)

For the last step of the procedure you will be assigned to a team. 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 your ranking number. The Teamwork Assignment consists of 3 parts:

1. You start by online introducing yourself to your team. You will have a few days (**Tuesday 11 to Thursday 13 March**) to write your introduction and meet your team.
2. You will come together online with your team during a chosen timeslot (either on **Monday 17 or Tuesday 18 March**) to participate in the team challenge.
3. After the challenge you will need to hand in a personal reflection before **Wednesday 19 March 23:59 CET**.

## Step 9 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 2025-2026. 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 10 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. Even after receiving a good ranking number, your application can be cancelled, for example if you do not have the right diploma or fail to pay the tuition fee in time.

## Taking the Cognitive Skills Test (CST)

The Cognitive Skills Test (selection test) contains the following three tests:

- Mathematics (40%)
- Systematic Reasoning & Logical Thinking (35%)
- Problem Solving (25%)

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 CST

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 [selectie-esa@tudelft.nl](mailto:selectie-esa@tudelft.nl). Requests need to be supported with official documentation, which is readable in English or Dutch and can be submitted after the registration deadline (15 January) and before **Friday 7 February 10:00 CET**. Read the extra time information in the [FAQ: 'Matching & Selection'](#), for the *mandatory* instructions on submitting your request.

### Tracks & CST

For candidates in the English track, the procedure will be entirely in English. Candidates in the Bilingual track will complete two of the three parts of the CST in Dutch (i.e. Mathematics and Problem Solving). The rest of the procedure will be in English and is the same for both tracks.

### Proctoring

To ensure an 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.**

### On campus CST

Candidates are offered the opportunity to take the CST on campus on **Saturday 8 March 11:00-14:00 CET**. The exam taken on campus will be done on a computer, but will *not* be proctored. There is a fixed number of seats to take the CST on Campus. If the number of candidates exceed the available seats for the campus CST day, seats will be randomly allocated among the candidates who choose this option. Candidates who did not get a seat will be assigned to their second (proctored) choice.

### CST dates

We offer the CST on set dates and within set time windows.

- ◆ Thursday 27 February ▪ 10:00-23:59 CET ▪ Proctored
- ◆ Wednesday 5 March ▪ 10:00-23:59 CET ▪ Proctored
- ◆ Saturday 8 March ▪ 11:00-14:00 CET ▪ Campus

It is not possible to take the CST on another date or time. At the beginning of the procedure you will be asked to submit your CST date preference.

## 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 are 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 or make a lot of noise which could distract you during the test.

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. Violation of these rules, and/or the rules listed below, can result in a sanction by the Selection Committee. All candidates taking the CST need to comply with the academic integrity standards of the [TU Delft](#). 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 or a rule violation, 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 **not** allowed
- A **calculator** is **not** allowed, nor is a calculator on another device
- Use of a **second computer** is **not** allowed
- Use of a (smart) **phone** is **not** allowed
- Use of **any other mobile device** than the device on which the test is taken is **not** allowed
- **Headphones** or **earplugs** are **not** allowed (even if they are only noise cancelling)
- It is **not** 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: *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 Problem Solving. Some elements you can prepare for and some elements not. You can find the specifics for each element below:

Be aware that if you aspire to perform well in the selection test, we strongly recommend that you prepare for the CST. You can start preparing for the CST before the Matching & Selection procedure begins.

### 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 on the 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 not 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 not find any official answers, nor do we provide any more than those already included in the book.



S. Hugtenburg & N. Yorke-Smith (2022) *Delftse Foundations of Computation 2nd Edition* Retrieved from [Delftse Foundations of Computation 2nd Edition](#)

### Problem Solving

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 Problem Solving part as this is an aptitude test.

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

The Matching part of the procedure consists of the studying at TU Delft 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. Other than that you cannot prepare for this part of the procedure.

### Overall time investment

The timeline at the end of this brochure shows an indication of how much time each step will cost. Take into consideration that most candidates spend around **10-20 hours on preparation for the CST** (including the preparation lecture) and that reading all our communication carefully also takes time!

## 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 (40%)
- Systematic Reasoning and Logical Thinking (35%)
- Problem Solving (25%)

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, your high school grades are *not* taken into account when calculating your ranking number.

## 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.

### \*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. Even after receiving a good ranking number, your application can be cancelled, for example if you do not have the right diploma or fail to pay the tuition fee in time.

## More information

- [Admission & Application](#)
- [BSc CSE Matching & Selection](#)
- [FAQ](#)
- [selection-bsc-cse@tudelft.nl](mailto:selection-bsc-cse@tudelft.nl)

# Timeline procedure

Application and Matching & Selection BSc CSE 2025/2026

## 1. Application

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

1<sup>st</sup> Oct - 15<sup>th</sup> Jan  
23:59 CET

Indication of time investment

## 2. Start Matching & Selection procedure

Including a survey, indication of selection test (CST) preference date and Teamwork timeslot.

21<sup>st</sup> Jan – 27<sup>th</sup> Jan  
23:59 CET

1 hour

## 3. Online Student Experience (OSE)

21<sup>st</sup> Jan – 3<sup>rd</sup> Feb  
23:59 CET

1-2 hours

## 4. CST Preparation lecture

Lecture is optional and can be followed online or on campus.

Week of 3 February,  
to be announced

2 hours

## 5. Confirmation CST date

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

Before 12<sup>th</sup> Feb

## 6. Trial Run Proctoring

Test the proctoring software on the computer you will use to take the CST.

12<sup>th</sup> Feb – 17<sup>th</sup> Feb  
23:59 CET

1 hour

## 7. Selection Test (CST)

Complete the three parts of the CST, proctored and on your own computer or take the CST on campus.

27<sup>th</sup> Feb or 5<sup>th</sup> March  
(proctored)  
8<sup>th</sup> March (on campus)

3 hours (+ x hours preparation time)

## 8. Teamwork Assignment

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

11<sup>th</sup> March – 19<sup>th</sup> Mar  
23:59 CET

2 hours

## 9. Ranking

Studielink informs student of rank#

15<sup>th</sup> April

## 10. Accept & Finalize

- A. Accept your spot within 2 weeks
- B. Finalize registration in Studielink (and Osiaan for international students)

# 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 and 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 be 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

$$\cos^2(x) + \sin^2(x) = 1 \quad (1)$$

Angle sum and difference identities

$$\cos(\alpha - \beta) = \cos(\alpha) \cos(\beta) + \sin(\alpha) \sin(\beta) \quad (2)$$

$$\cos(\alpha + \beta) = \cos(\alpha) \cos(\beta) - \sin(\alpha) \sin(\beta) \quad (3)$$

$$\sin(\alpha - \beta) = \sin(\alpha) \cos(\beta) - \cos(\alpha) \sin(\beta) \quad (4)$$

$$\sin(\alpha + \beta) = \sin(\alpha) \cos(\beta) + \cos(\alpha) \sin(\beta) \quad (5)$$

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

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

Double-angle formulae

$$\cos(2x) = \cos^2(x) - \sin^2(x) \quad (8)$$

$$= 2 \cos^2(x) - 1 \quad (9)$$

$$= 1 - 2 \sin^2(x) \quad (10)$$

$$\sin(2x) = 2 \sin(x) \cos(x) \quad (11)$$

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

## Integrals

$$\int x^a \, dx = \frac{x^{a+1}}{a+1} + C \quad (a \neq -1) \quad (13)$$

$$\int a^x \, dx = \frac{a^x}{\ln(a)} + C \quad (a \neq 1) \quad (14)$$

$$\int \frac{1}{x} \, dx = \ln|x| + C \quad (15)$$

$$\int e^x \, dx = e^x + C \quad (16)$$

$$\int \ln(x) \, dx = x \ln(x) - x + C \quad (17)$$

$$\int \log_a(x) \, dx = \frac{1}{\ln(a)}(x \ln(x) - x) + C \quad (a > 0 \text{ and } a \neq 1) \quad (18)$$

$$\int \sin(x) \, dx = -\cos(x) + C \quad (19)$$

$$\int \cos(x) \, dx = \sin(x) + C \quad (20)$$