

- Visual Studio Code<sup>11</sup>
- Dafny download and more<sup>12</sup>
- On the web page <https://tio.run/#dafny> it is possible to write and compile Dafny code.
- The Youtube channel Verification Corner<sup>13</sup> with Rustan Leino and colleagues.
  - 0:** Basics of specification and verification: Lecture 0<sup>14</sup>, Pre- and postconditions
  - 1:** Basics of specification and verification: Lecture 1<sup>15</sup>, loop invariants
  - 2:** Basics of specification and verification: Lecture 2<sup>16</sup>, binary search
  - 3:** Basics of specification and verification: Lecture 3<sup>17</sup>, the Dutch National Flag algorithm — tengist Dijkstra quicksort sem við munum ræða seinna — góð umfjöllun fyrir utan skýringarmyndina fyrir fastayrðingu lykkju sem er gölluð og villandi
- An example on Youtube** (not Dafny but rather Spec#, which is similar): More on loop invariants<sup>18</sup> along with computations of a sequence of  $n^3$  values without multiplication – Rustan Leino

## 15 Efni vikunnar

Við munum fjalla um grundvallaratriði rökfræði og röksemdafærslu forrita og einnig sjá dæmi í Dafny. Finnið glærur vikunnar í Canvas og horfið á myndskeið vikunnar í Panopto/Canvas.

## 16 This Weeks Topics

We will discuss the basics of logic and program validation and also see examples in Dafny. Find the slides of the week in Canvas and watch the videos of the week in Panopto/Canvas.

## 17 Verkefni

Skilið lausnum verkefnanna sem PDF í Gradescope innan þeirra tímamarka sem skilgreind eru þar. Sendið einnig lausnina í tölvupósti til mín ([snorri@hi.is](mailto:snorri@hi.is)) eða setjið stutt permalink á lausnina fremst í lausnina.

<sup>11</sup><https://code.visualstudio.com/Download>

<sup>12</sup><https://dafny.org/>

<sup>13</sup><https://www.youtube.com/channel/UCP2eLEql4tROYmIYm5mA27A>

<sup>14</sup>[https://www.youtube.com/watch?v=oLS\\_y842fMc](https://www.youtube.com/watch?v=oLS_y842fMc)

<sup>15</sup>[https://www.youtube.com/watch?v=J0FGb6PyO\\_k](https://www.youtube.com/watch?v=J0FGb6PyO_k)

<sup>16</sup>[https://www.youtube.com/watch?v=-\\_tx3lk7yn4](https://www.youtube.com/watch?v=-_tx3lk7yn4)

<sup>17</sup><https://www.youtube.com/watch?v=dQC5m-GZYbk>

<sup>18</sup><https://www.youtube.com/watch?v=spcfzbisBv4>

**Einstaklingsverkefni.** Notið Dafny til að sanna formúluna

$$\sum_{k=1}^n (2k - 1) = n^2$$

þ.e.

$$1 + 3 + 5 + \dots + (2n - 1) = n^2$$

með því að klára forritstextann í skránni `SumOdds-skeleton.dfy` sem þið finnið í Canvas. Þið munið þá hafa sannað formúluna á þrjá vegu, sem allir eru eitthvert afbrigði af vélrænni þrepasönnun. Til hliðsjónar er ráðlegt að lesa glærur viku 1 (einnig í Canvas) þar sem sannað er að

$$\sum_{i=1}^n i = \frac{n(n+1)}{2}$$

þ.e.

$$1 + 2 + 3 + \dots + n = \frac{n(n+1)}{2}$$

**Hópverkefni.** Klárið forritunina í skránni `LinearSearch-skeleton.dfy`, sem þið finnið í Canvas, á tvo vegu, með lykkju og með endurkvæmni. Ekki má breyta lýsingu fallsins sem skilgreint er að öðru leyti en því að leyfilegt er að bæta við „decreases“ klausu.

Í báðum þessum verkefnum þurfið þið að sjá til þess að Dafny þýðandinn samþykki forritstextann, sem tryggir þá að öll föllin virka samkvæmt sinni lýsingu.

## 18 Assignments

Turn in the solutions as PDF files in Gradescope within the timeframe defined there. Also send the solution to me via email ([snorri@hi.is](mailto:snorri@hi.is)) or put a short permalink to the solution at the beginning of the solution.

**Individual Assignment.** Use Dafny to prove the formula

$$\sum_{k=1}^n (2k - 1) = n^2$$

i.e.

$$1 + 3 + 5 + \dots + (2n - 1) = n^2$$

by finishing coding the program in the file `SumOdds-skeleton.dfy` which you will find in Canvas. You will then have proved the formula in three ways, which are all some variant of computerized induction. For reference it is useful to read the slides of the week (also in Canvas) where it is proven that

$$\sum_{i=1}^n i = \frac{n(n+1)}{2}$$

i.e.

$$1 + 2 + 3 + \dots + n = \frac{n(n+1)}{2}$$

**Group Assignment.** Finish the programming in the file `LinearSearch-skeleton.dfy`, which you will find in Canvas, in two ways, with a loop and with recursion. The description of the function may not be changed except that it is allowed to add a "decreases" clause.

In both these assignments you must ensure that the Dafny compiler accepts the source code, which then ensures that the functions work according to their descriptions.