

## Uses of Greek Letters and Other Symbols in CMPSCI 601

| letter     | name    | typical uses in CMPSCI 601                              |
|------------|---------|---|
| $\alpha$   | alpha   | formula, etc.   |
| $\beta$    | beta    | formula   |
| $\gamma$   | gamma   | formula   |
| $\Gamma$   | Gamma   | alphabet, vocabulary, set of formulas                   |
| $\delta$   | delta   | formula, transition function                            |
| $\Delta$   | Delta   | change = new - old                                      |
| $\epsilon$ | epsilon | empty string, small positive real number                |
| $\zeta$    | zeta    | constant zero function                                  |
| $\eta$     | eta     | mapping   |
| $\theta$   | theta   | formula   |
| $\Theta$   | Theta   |   |
| $\iota$    | iota    |   |
| $\kappa$   | kappa   | cardinal number, program counter                        |
| $\lambda$  | lambda  | function abstraction, e.g., $\lambda x(x^2)$            |
| $\mu$      | mu      | interpretation function on terms, minimization function |
| $\nu$      | nu      |   |
| $\xi$      | xi      |   |
| $\omicron$ | omicron |   |
| $\pi$      | pi      | 3.14159265..., prime number                             |
| $\Pi$      | Pi      | set of predicate symbols, proof, product                |
| $\rho$     | rho     |   |
| $\sigma$   | sigma   | successor function, symbol in $\Sigma$                  |
| $\Sigma$   | Sigma   | alphabet, vocabulary, set of formulas, sum              |
| $\tau$     | tau     |   |
| $\Upsilon$ | Upsilon |   |
| $\varphi$  | phi     | formula   |
| $\Phi$     | Phi     | set of formulas, SO formula, set of function symbols    |
| $\chi$     | chi     | characteristic function                                 |
| $\psi$     | psi     | formula   |
| $\Psi$     | Psi     | set of formulas, second-order formula                   |
| $\omega$   | omega   | formula   |
| $\Omega$   | Omega   | lower bound $\Omega(f(n))$                              |

| symbol                   | name                   | typical meaning or uses in CMPSCI 601                                      |
|--------------------------|------------------------|--|
| #                        | number sign            | separator, $\#_a(w)$ = number of $a$ 's in $w$                             |
| *                        | star                   | $\Sigma^*$ = set of all finite words from $\Sigma$                         |
| $\leq$                   | less than or equal     | less than or equal; is reducible to; substructure of                       |
| $\cap$                   | intersection           | intersection   |
| $\cup$                   | union                  | union  |
| $\perp$                  | bottom                 | “false” in a logical formula   |
| $\square$                | box                    | end of proof, definition, etc.   |
| $\cdot$                  | cdot                   | indicates place for an argument, multiplication                            |
| $\circ$                  | circ                   | composition or concatenation   |
| $\Rightarrow \Leftarrow$ | Contradiction          | contradiction in informal (metamathematical) statement                     |
| $\cong$                  | iso                    | isomorphic   |
| $\downarrow$             | downarrow              | $M(w)\downarrow$ means $M$ converges on input $w$                          |
| $\emptyset$              | emptyset               | emptyset   |
| $\equiv$                 | equiv                  | equivalent, semantically equivalent, elementarily equivalent               |
| $\leftrightarrow$        | is an abbreviation for | e.g., $(\alpha \rightarrow \beta) \leftrightarrow (\neg\alpha \vee \beta)$ |
| $\exists$                | exists                 | there exists   |
| $\forall$                | forall                 | for all  |
| $\lceil \cdot \rceil$    | ceiling                | smallest integer greater than or equal to                                  |
| $\lfloor \cdot \rfloor$  | floor                  | largest integer less than or equal to                                      |
| iff                      | iff                    | if and only if   |
| $\wedge$                 | land                   | logical and  |
| $\vee$                   | lor                    | logical or   |
| $\neg$                   | lnot                   | logical not  |
| $\rightarrow$            | rightarrow             | implies in a logical formula   |
| $f : A \rightarrow B$    | rightarrow             | $f$ is a function from $A$ to $B$  |
| $\mapsto$                | mapsto                 | $a \mapsto b$ means that the map takes $a$ to $b$                          |
| $\Rightarrow$            | Rightarrow             | implies in informal (metamathematical) statement                           |
| $\Leftrightarrow$        | leftrightarrow         | iff in a logical formula   |
| $\Leftrightarrow$        | Leftrightarrow         | iff in informal (metamathematical) statement                               |
| log                      | log                    | log base 2   |
| $\models$                | models                 | $\mathcal{A} \models \varphi$ means “ $\varphi$ is true in $\mathcal{A}$ ” |
| $\vdash$                 | proves                 | $\Gamma \vdash \varphi$ means “ $\varphi$ can be proved from $\Gamma$ ”    |
| $\downarrow$             | downarrow              | $M(w)\downarrow$ means $M$ converges on input $w$                          |
| $\nearrow$               | nearrow                | $M(w) = \nearrow$ means $M$ diverges on input $w$                          |
| $\oplus$                 | oplus                  | exclusive or, sum mod 2  |
| $\sim$                   | sim                    | has same cardinality, is equivalent to                                     |
| $\wp$                    | power set              | $\wp(S) = \{A \mid A \subseteq S\}$  |
| $\sqcup$                 | sqcup                  | space symbol on TM tape  |
| $\subseteq$              | subsetq                | subset or equal to   |
| $\subsetneq$             | psubset                | proper subset of   |
| $\top$                   | top                    | “true” in a logical formula  |
| $\triangleright$         | triangleright          | left marker on TM tape   |

| other letters | name    | typical meaning or uses in CMPSCI 601                                 |
|---------------|---------|---|
| $\mathcal{A}$ | cal A   | logical structure   |
| $\mathcal{B}$ | cal B   | logical structure   |
| $\mathcal{C}$ | cal C   | complexity class  |
| $\mathcal{L}$ | cal L   | language, $\mathcal{L}(M) =$ language accepted by $M$                 |
| $\mathbf{N}$  | bf N    | the set of natural numbers, $\mathbf{N} = \{0, 1, 2, \dots\}$         |
| $\mathbf{Q}$  | bf Q    | the set of rational numbers   |
| $\mathbf{R}$  | bf R    | the set of real numbers   |
| $\mathbf{Z}$  | bf Z    | the set of integers, $\mathbf{Z} = \{\dots, -2, -1, 0, 1, 2, \dots\}$ |
| $\aleph_0$    | aleph 0 | cardinality of $\mathbf{N}$   |

| name   | Complexity Measures    |
|--------|------------------------|
| DSPACE | deterministic space    |
| NSPACE | nondeterministic space |
| DTIME  | deterministic time     |
| NTIME  | nondeterministic time  |
| ASPACE | alternating space      |
| ATIME  | alternating time       |

| name                | Complexity Classes   |
|---------------------|--|
| r.e.                | recursively enumerable sets                                |
| co-r.e.             | sets whose complements are r.e.                            |
| Recursive           | recursive sets   |
| Primitive Recursive | primitive recursive sets                                   |
| EXPTIME             | exponential time $\text{DTIME}[2^{n^{O(1)}}]$              |
| PSPACE              | polynomial space $\text{DSPACE}[n^{O(1)}]$                 |
| PH                  | polynomial-time hierarchy                                  |
| NP                  | nondeterministic polynomial time, $\text{NTIME}[n^{O(1)}]$ |
| P                   | polynomial time, $\text{DTIME}[n^{O(1)}]$                  |
| NL                  | nondeterministic logspace, $\text{NSPACE}[\log n]$         |
| L                   | logspace, $\text{DSPACE}[\log n]$                          |
| CFL                 | context-free languages                                     |
| Regular             | regular languages  |