

TRANSATOMIC – schon wieder ein neuer Reaktortyp?



Gänzlich anders als in Deutschland, in dem man sich mehr denn je zurück ins Mittelalter träumt, setzt man in USA verstärkt auf die Ausbildung junger Ingenieure und Wissenschaftler und ermutigt sie, eigene Unternehmen zu gründen. Eines der Programme ist das Gateway for Accelerated Innovation in Nuclear (GAIN), des U.S. Department of Energy (DOE). Vereinfacht gesagt, gibt es dort Gutscheine, die die (sonst kostenpflichtige) Nutzung staatlicher Forschungseinrichtungen durch Unternehmensgründungen ermöglicht. Acht solcher "Gutscheine" im Gesamtwert von zwei Millionen Dollar gingen an sog. startups aus der Kerntechnik.

Eines dieser jungen Unternehmen der Kerntechnik ist Transatomic Power Corporation (TPC). Wie so oft in den USA, ist es eine Gründung von Absolventen des MIT. Glückliches Amerika, in dem noch immer tausende junger Menschen bereit sind, sich den Strapazen eines Kerntechnik-Studienganges aussetzen, während man hierzulande lieber "irgendwas mit Medien" studiert. Allerdings kennt man in den USA auch keine Zwangsgebühren zur Schaffung von hoch dotierten Nachrichtenvorlesern und Volksbelehrern. Jeder Staat setzt halt seine eigenen Prioritäten.

Noch etwas ist in den USA völlig anders. Das junge Unternehmen hat bereits mehrere Millionen Dollar privates Risikokapital eingesammelt. Es braucht noch mehr Kapital und hat deshalb ein Papier veröffentlicht, in dem das Konzept seines Reaktors näher beschrieben ist. Sicherlich ein erhebliches wirtschaftliches Risiko. Man vertraut offensichtlich darauf, mangelnde "Geldmacht" durch Schnelligkeit kompensieren zu können. Erklärtes Ziel ist es, möglichst schnell einen kleinen Versuchsreaktor mit 20 MWth zu bauen. Das erste kommerzielle Kraftwerk soll rund 500 MWe (1250 MWth) Leistung haben und rund zwei Milliarden Dollar kosten.

Abgebrannte Brennelemente als Brennstoff

Der Reaktor ist vom Typ "molten salt". Der Brennstoff wird in geschmolzenem Salz gelöst, welches gleichzeitig dem

Wärmetransport dient. Populär ist dieser Reaktortyp im Zusammenhang mit Thorium gemacht worden. Man beschränkt sich hier bewußt auf Uran als Brennstoff, um auf die dafür vorhandene Infrastruktur zurückgreifen zu können. Thorium wird eher als Option in ferner Zukunft gesehen.

Der besondere Charme dieses Konzeptes liegt in der Verwendung abgebrannter Brennelemente aus Leichtwasserreaktoren als Brennstoff. Solche abgebrannten Brennelemente bestehen zu rund 95% aus Uran-238 und etwa je einem Prozent Uran-235 und Plutonium. Der Rest sind Spaltprodukte als Abfall. Das klassische Modell, wie es z.B. in Frankreich praktiziert wird, ist die Wiederaufbereitung nach dem Purex-Verfahren: Man erhält sehr reines Uran, welches als Ersatz für Natururan wieder in den Kreislauf zurückgeführt wird und reines Plutonium, welches als Mischoxid zu

neuen Brennelementen verarbeitet wird. Die Spaltprodukte mit Spuren von Aktinoiden werden verglast und als Atommüll endgelagert. Für diese chemischen Prozeßschritte (Wiederaufbereitungsanlage) geht man von Kosten in Höhe von 1300 bis 3000 US-Dollar pro kg aus. Bei heutigen Preisen für Natururan eine unwirtschaftliche Angelegenheit. Deshalb füllen sich die Lager mit abgebrannten Brennelementen auch weiterhin. Allein in den USA lagern über 70.000 to ausgedienter Brennelemente. Für die "Zwischenlagerung" in Behältern (ähnlich den Castoren in Deutschland) geht man von etwa 100 Dollar pro kg aus. Für die "Entsorgung" haben sich bereits über 31 Milliarden US-Dollar Rücklagen angesammelt – was etwa 400 Dollar pro kg entspricht.

Wem es gelingt, einen Reaktor zu bauen, der die abgebrannten

Brennelemente “frißt”, ist in der Rolle einer Müllverbrennungsanlage: Er wird für die Beseitigung des Mülls bezahlt und kann sich mit seinem Preis an den anderen Möglichkeiten (z. B. Müllkippe) orientieren. Die entstehende Wärme ist umsonst. Die elektrische Energie aus der “Müllbeseitigung” ist ein weiteres Zubrot. Es kommt lediglich darauf an, eine besonders günstige “Müllverbrennungsanlage” zu bauen. Genau an diesem Punkt, setzt TPC an.

Das Transatomic Konzept

Die Angst vor dem “Atommüll” wird mit seiner

**Langlebigkeit
begründet. Es gibt
wahrlich
gefährlichere
Stoffe, als
abgebrannte
Brennelemente.
Solange man sie
nicht aufisst, sind
sie recht harmlos.
Es ist aber die
berechtigte Angst,**

**ob man diese Stoffe
für Jahrmillionen
sicher von der
Biosphäre fern
halten kann, die
viele Menschen
umtreibt.**

**Spaltprodukte sind
in diesem Sinne
kein Problem, da
sie in wenigen
hundert Jahren**

**faktisch von selbst
verschwunden sind.
Jahrhunderte sind
aber durch
technische Bauwerke
(Kathedralen,
Pyramiden etc.)
oder natürliche
Barrieren (einige
hundert Meter
gewachsene
Erdschichten)**

**sicher
beherrschbar.**

**Man kann aber alle
langlebigen
Aktinoide durch
Spaltung in
kurzlebige
Spaltprodukte
umwandeln und dabei
noch riesige Mengen
Energie erzeugen –
am besten in einem**

Kernkraftwerk. Ein solcher Reaktor muß besonders sparsam mit den bei einer Spaltung freiwerdenden Neutronen umgehen, um möglichst viele andere Kerne umzuwandeln und letztendlich zu spalten.

Spaltprodukte haben teilweise sehr große Einfangquerschnitte. Mit anderen Worten, sie wirken parasitär indem sie wertvolle Neutronen "wegfangen". Die Konsequenz ist eine integrierte Wiederaufbereitung.

**Dies läßt sich nur
über eine
Brennstofflösung
erreichen.**

**Es dürfen nur
möglichst wenig
Neutronen das
System verlassen.
Dazu muß man den
Reaktor mit einem
Reflektor versehen,
der die Neutronen**

**wieder in den
Reaktor zurück
streut.**

**Idealerweise
verwendet man dafür
ebenfalls Uran,
damit nicht zurück
streubare Neutronen
bei ihrem Einfang
wenigstens neuen
Spaltstoff – hier
Plutonium –**

erzeugen.

**Bei Reaktoren mit
festen**

**Brennstoffen, kann
man die Spaltstoffe
nicht**

**kontinuierlich
ersetzen. Man**

**benötigt deshalb zu
Anfang eine**

**Überschußreaktivität.
So zu sagen,**

**mehr Spaltstoff als
eigentlich
zuträglich ist.**

**Diese
Überschußreaktivität
muß durch
Regelstäbe und
abbrennbare Gifte
kompensiert werden:
Wertvolle Neutronen
werden unnütz weg
gefangen.**

**Will man mit
möglichst geringer
Anreicherung
auskommen – was
einem bereits
abgebrannten
Brennelement
entspricht – muß
man zwingend auf
ein thermisches
Neutronenspektrum
übergehen.**

**Sogenannte
“Schnelle Brüter”
erfordern eine
zweistellige
Anreicherung. Also
wesentlich höher,
als sie in einem
frischen
Brennelement für
einen
Leichtwasserreaktor
vorliegen. Man kann**

**in einem
thermischen Reaktor
zwar nicht brüten –
also mehr
Spaltstoff erzeugen
als beim Betrieb
verbraucht wird –
aber fast genau
soviel erzeugen,
wie verbraucht
wird. Man muß es
auch gar nicht, da**

**ja der "Atommüll"
noch Spaltstoff
enthält.**

**Wieviele
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Ein

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**Brennelemente pro
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Geht man

**von einer
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ng aus,
ist dies
die Menge**

**“Atommüll
” die in
ein
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muß.
Erzeugt**

**man die
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**Energie
aus eben**

solchem

“Atommüll

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diese

Menge

schon mal

**komplett
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**Gleichzei
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aber auch

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**“Atommüll
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Sie sind

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Spaltung
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**Uran noch
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als
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**und damit
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Plutonium

für sie

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**Stoffgruppe
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aber bei
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**Brennstof
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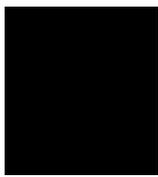
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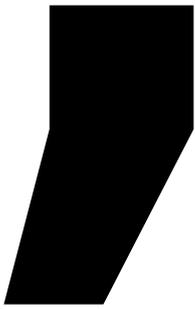
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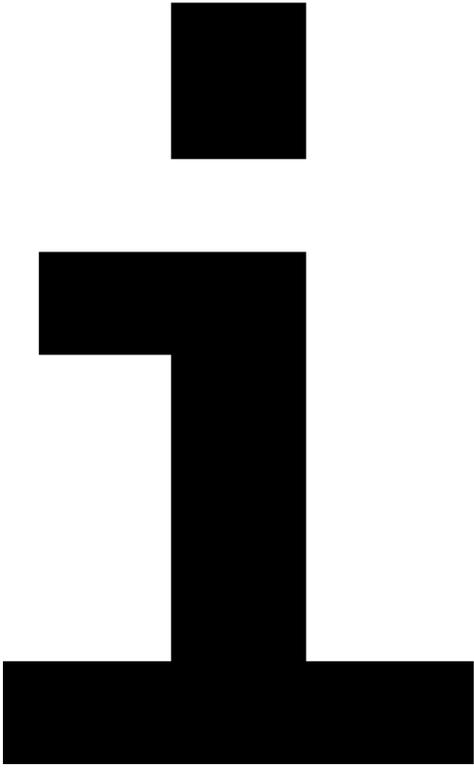
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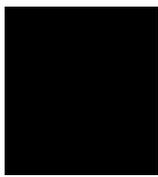
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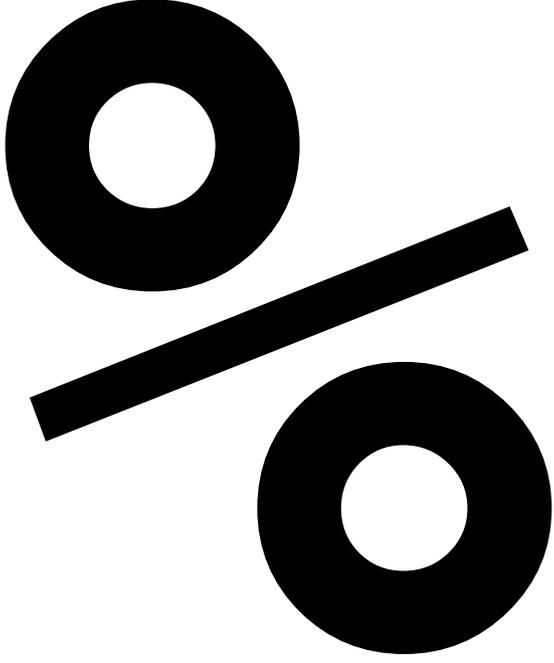
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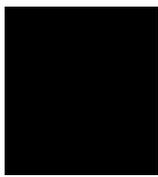
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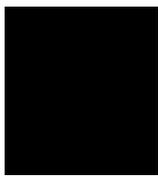
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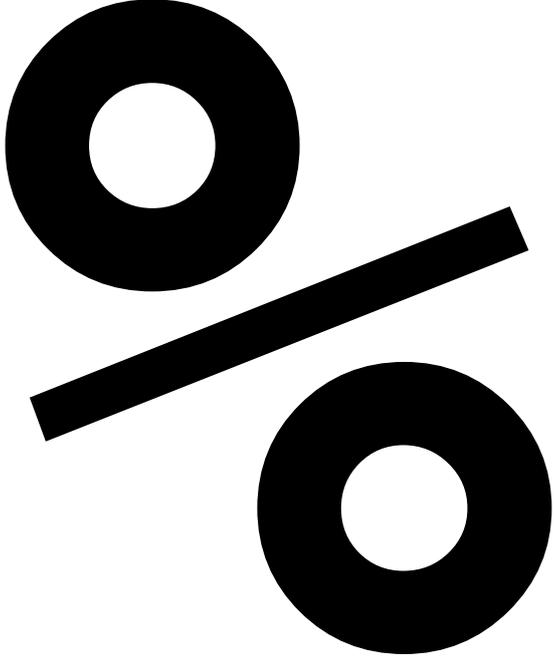
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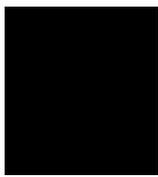
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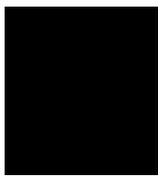
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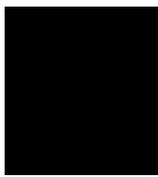
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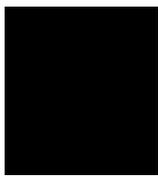
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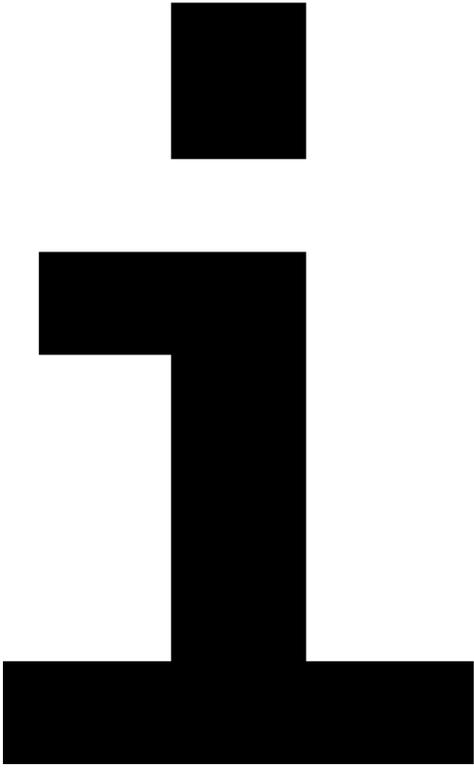
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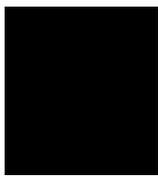
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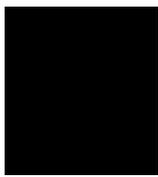
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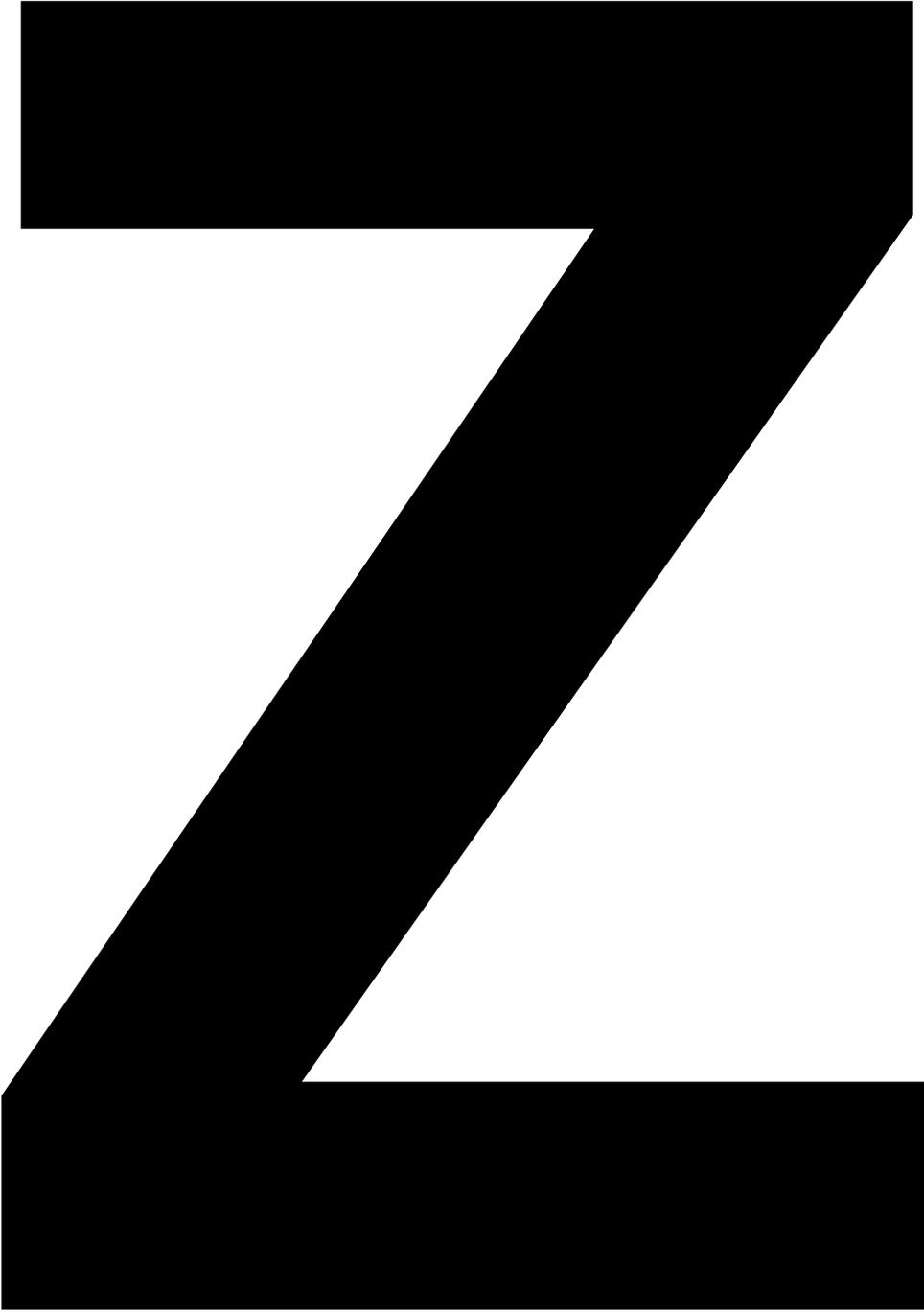
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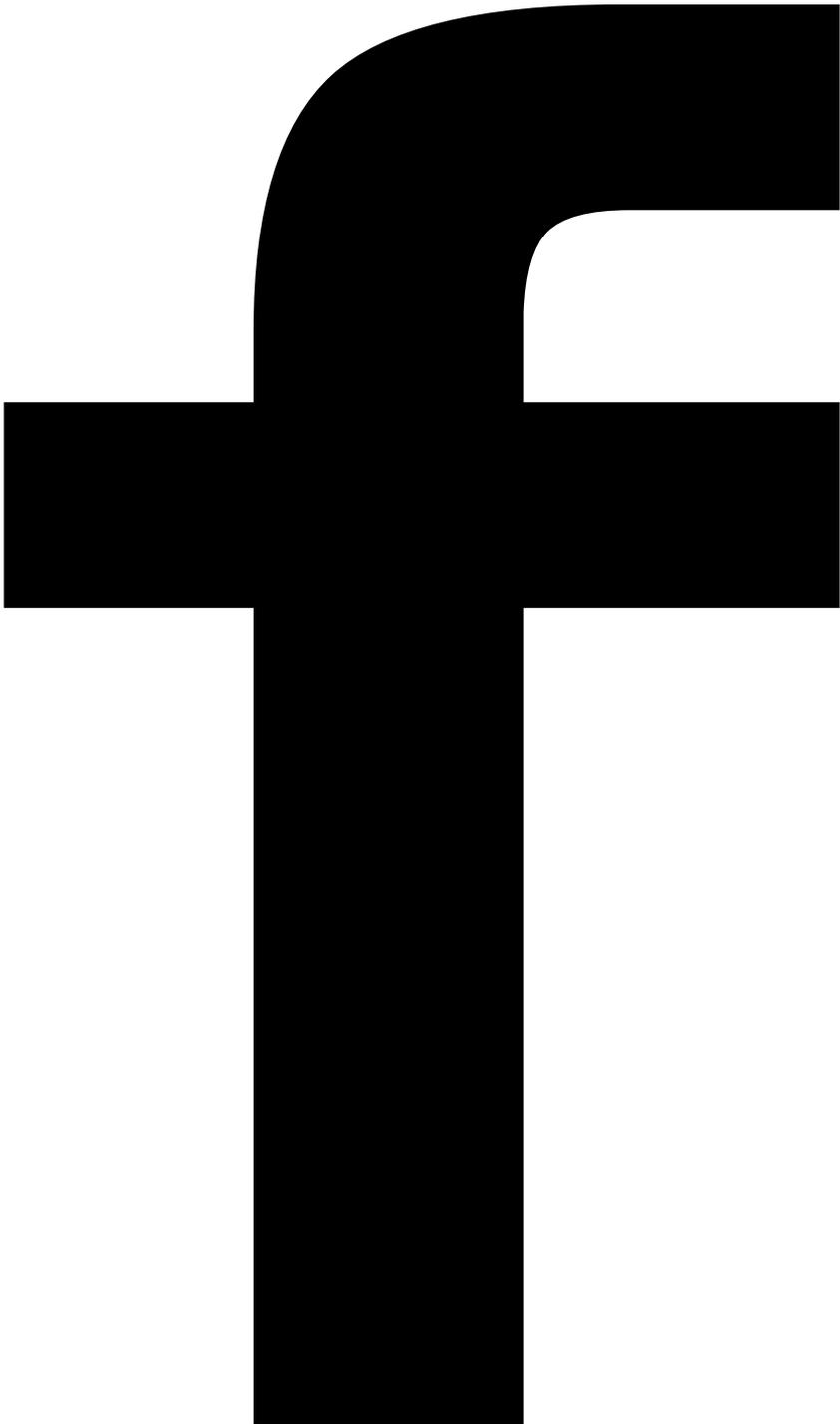
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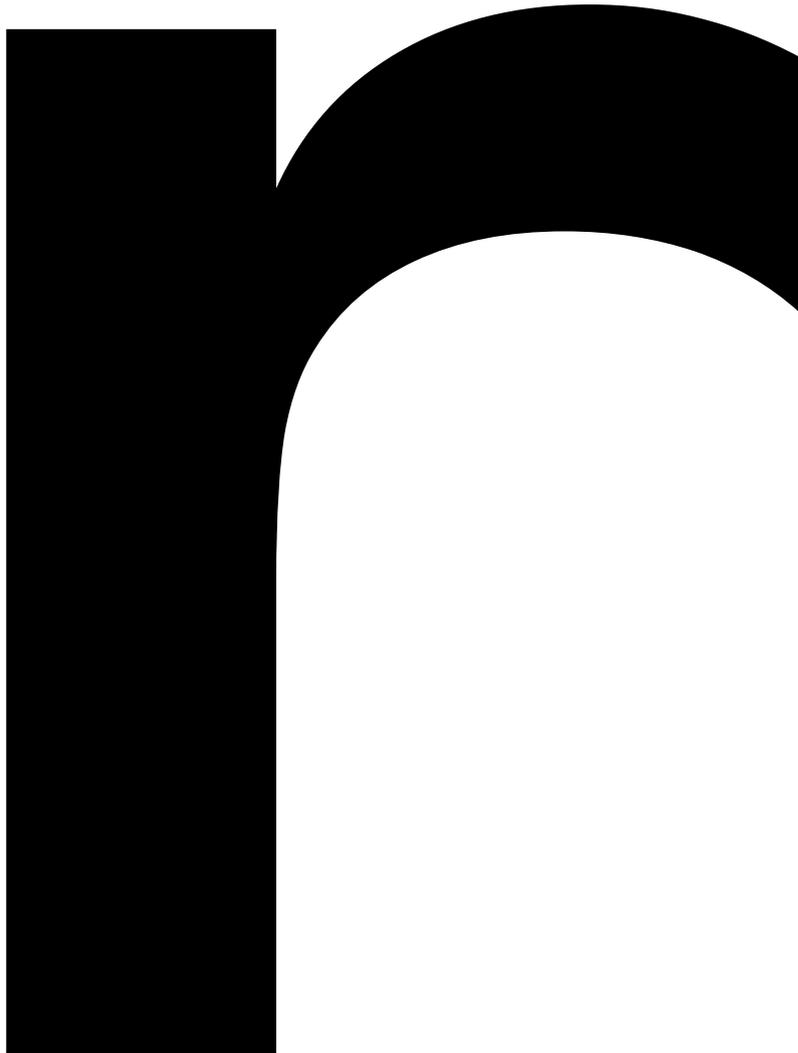
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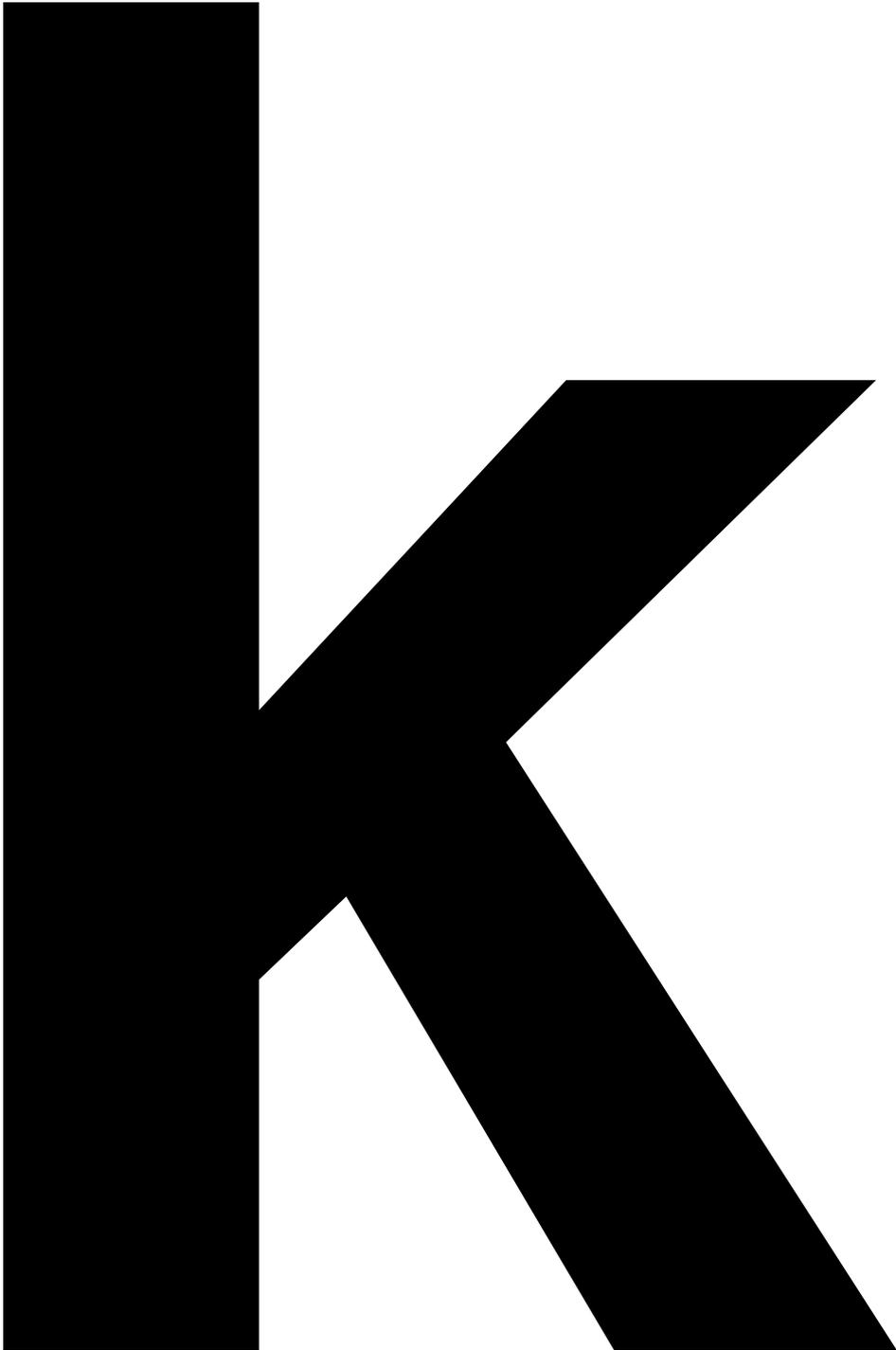
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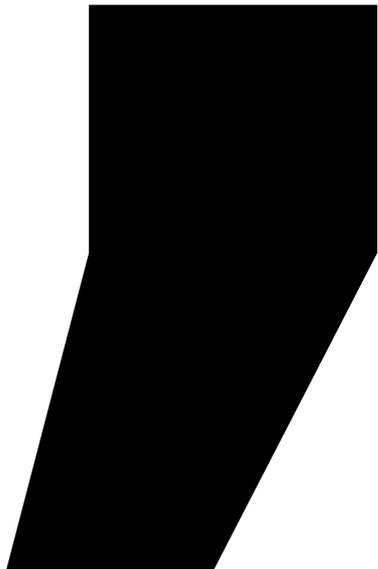
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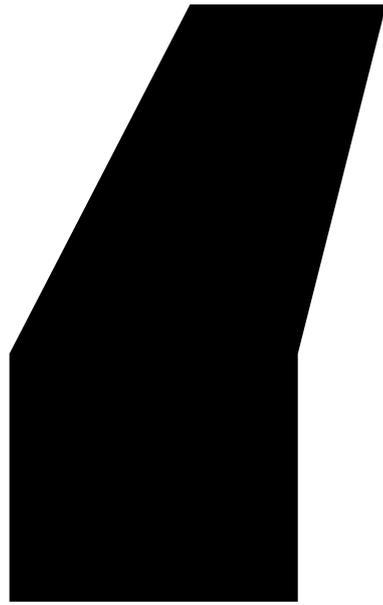
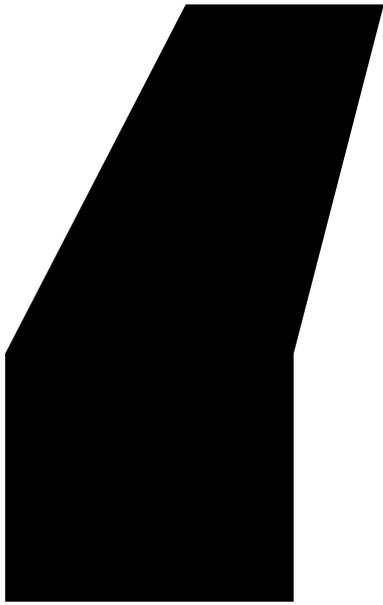
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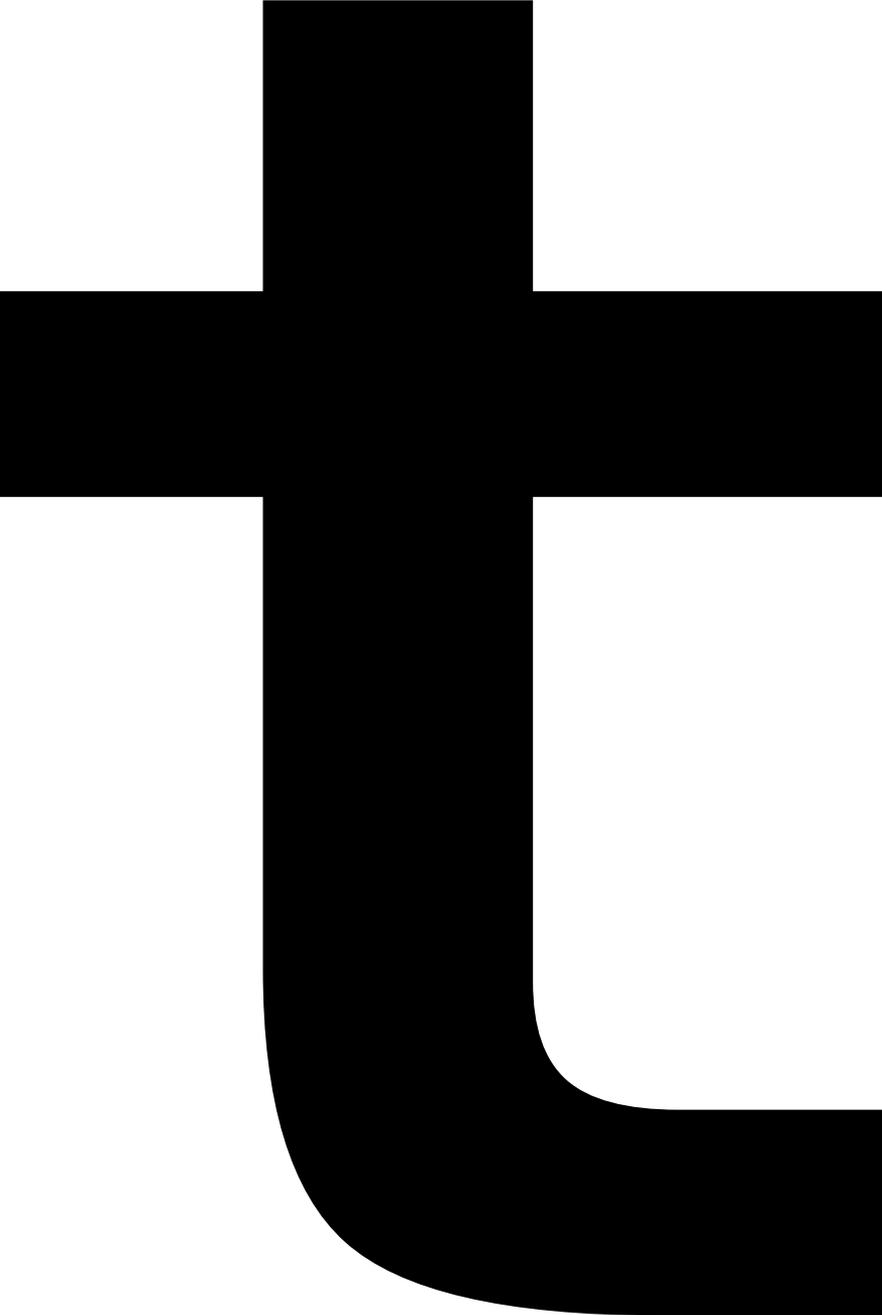


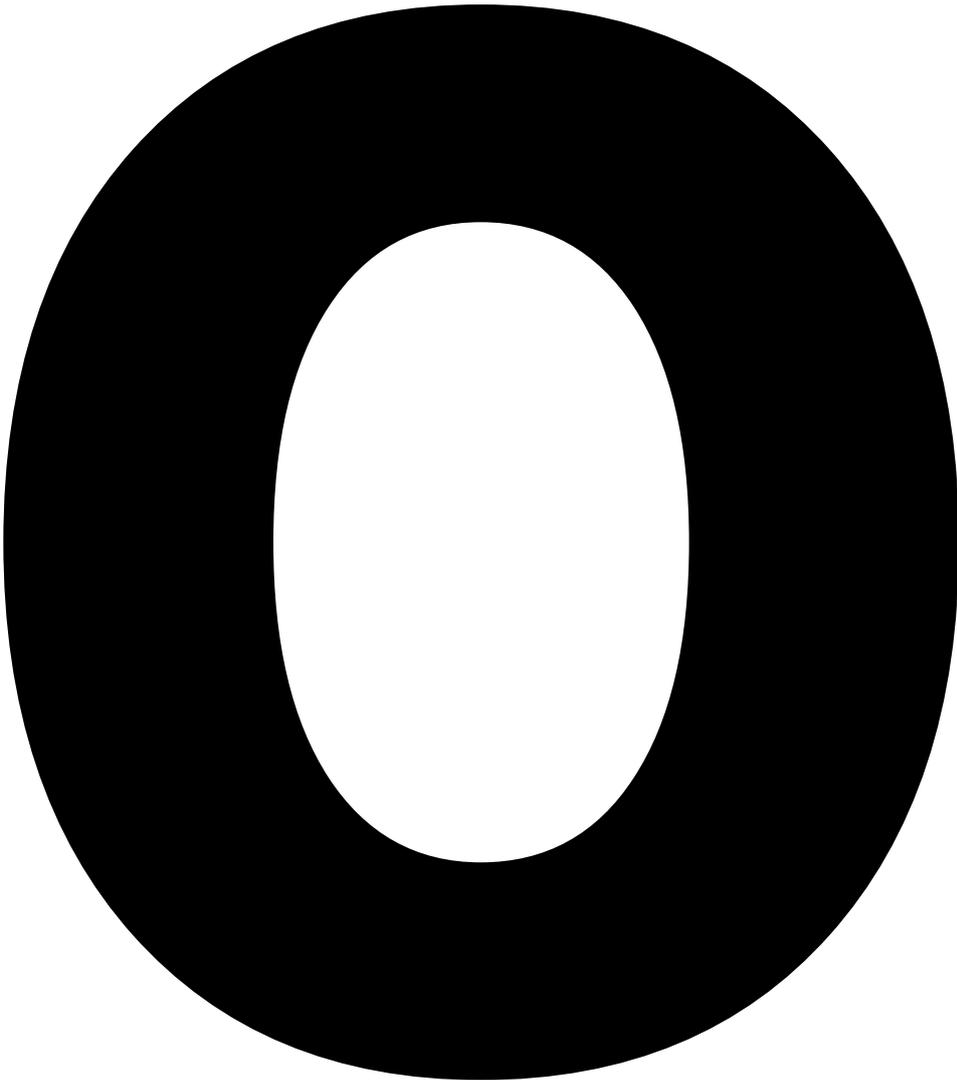
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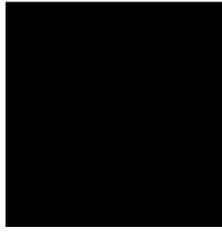
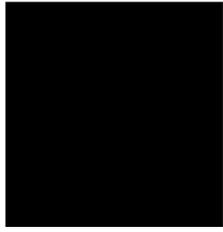
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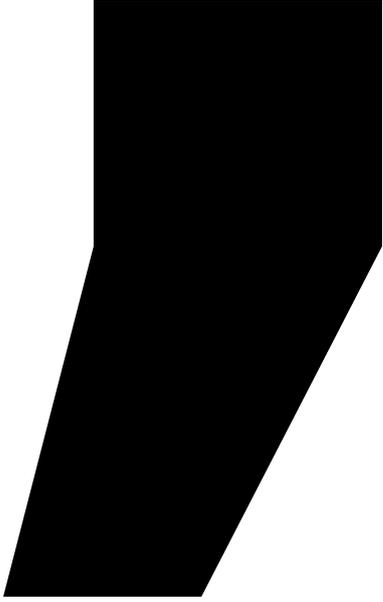
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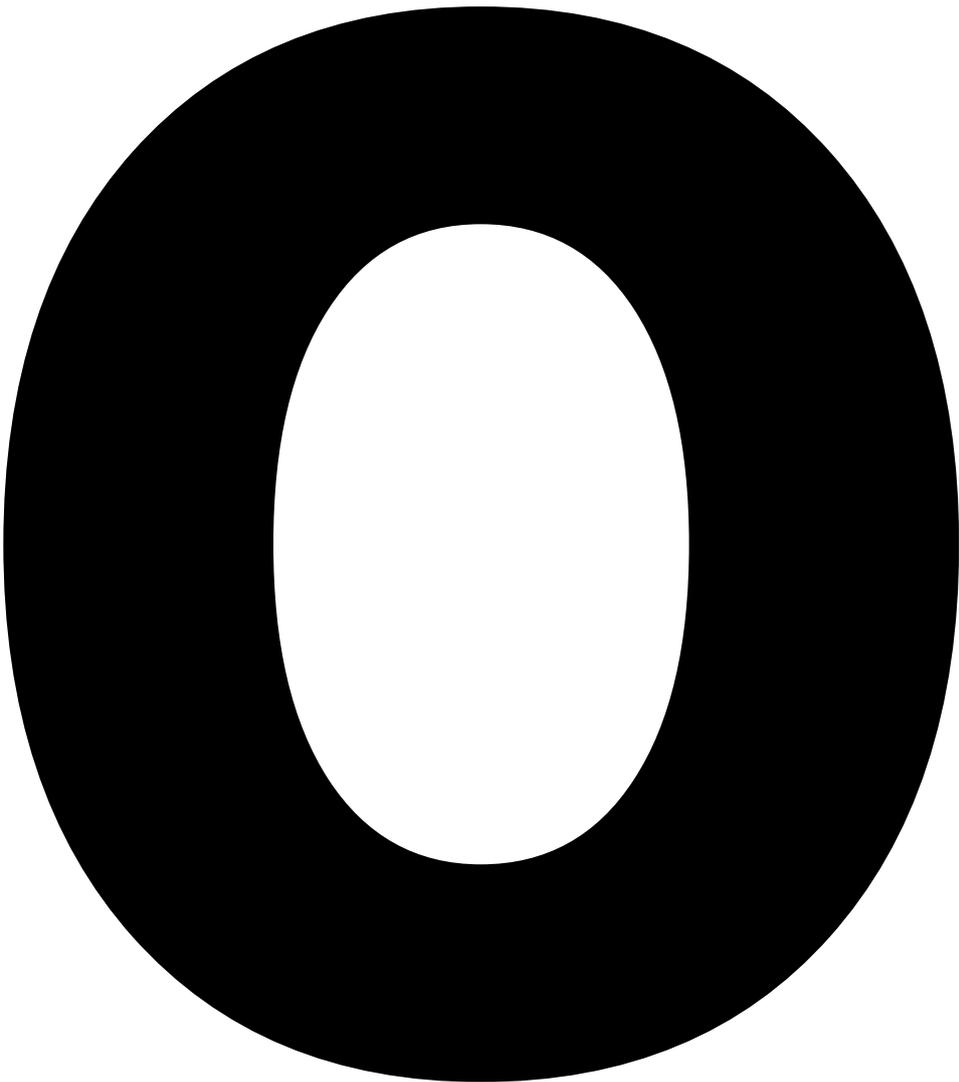
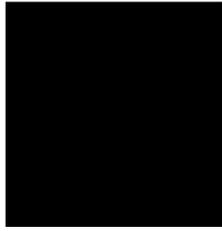
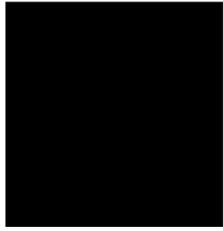
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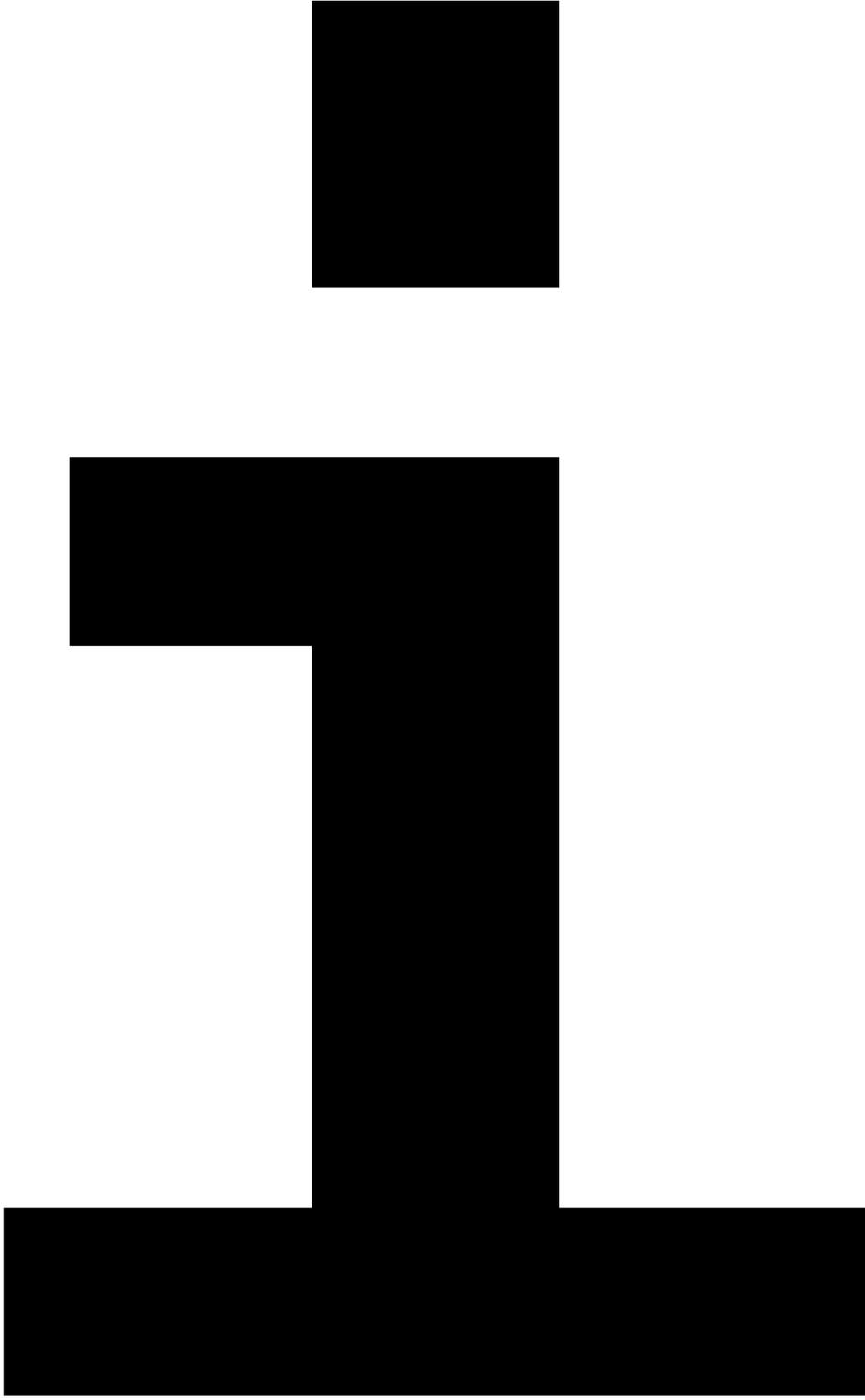


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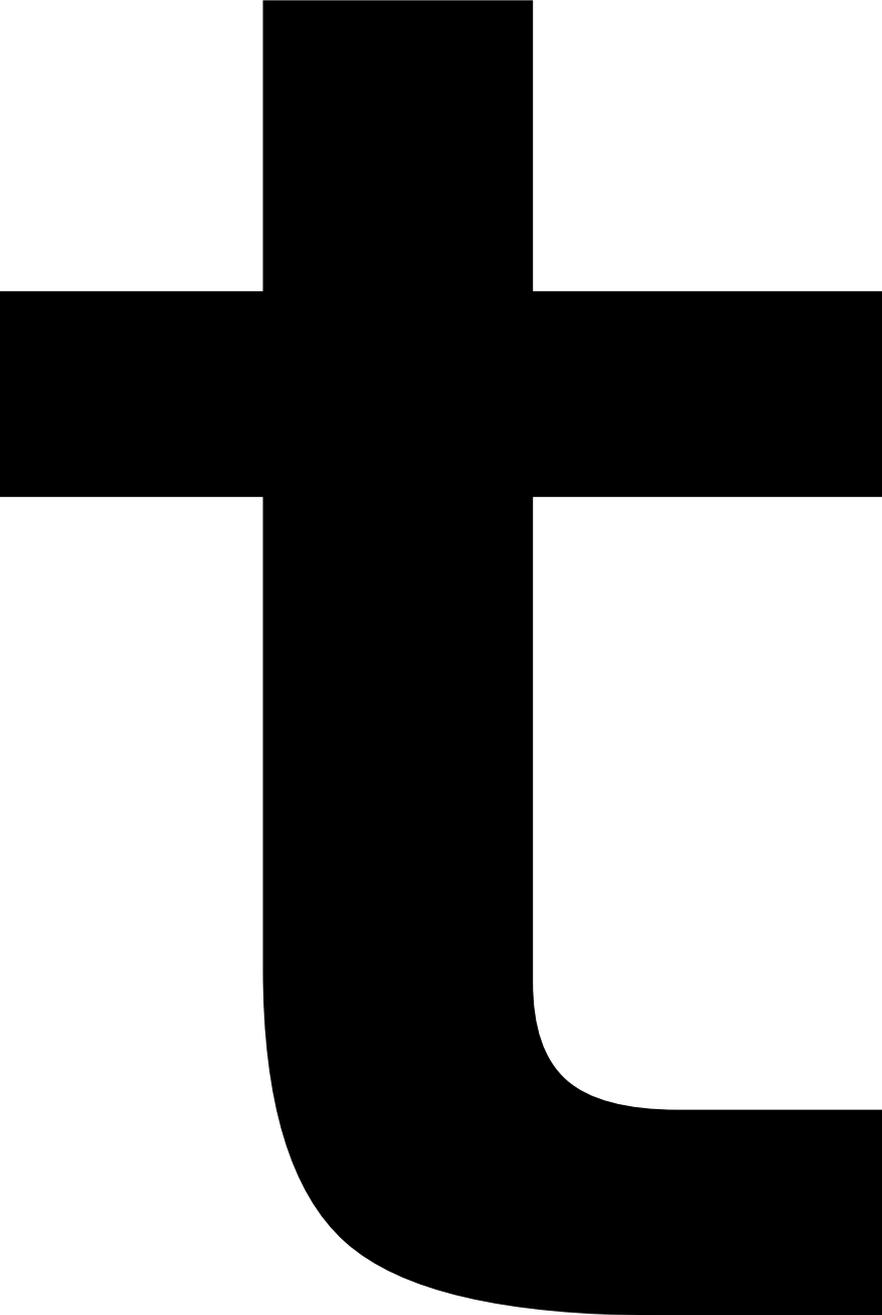
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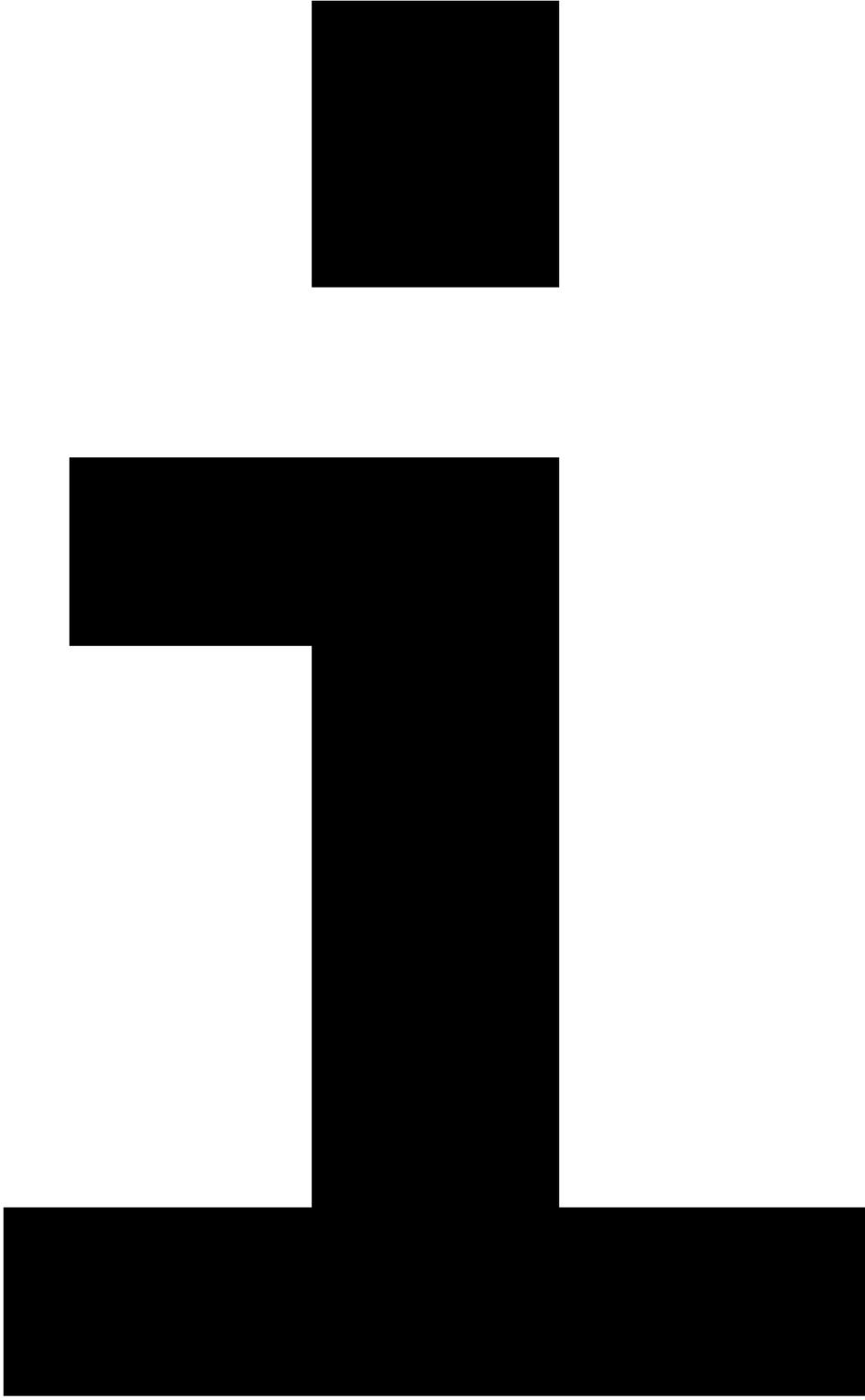
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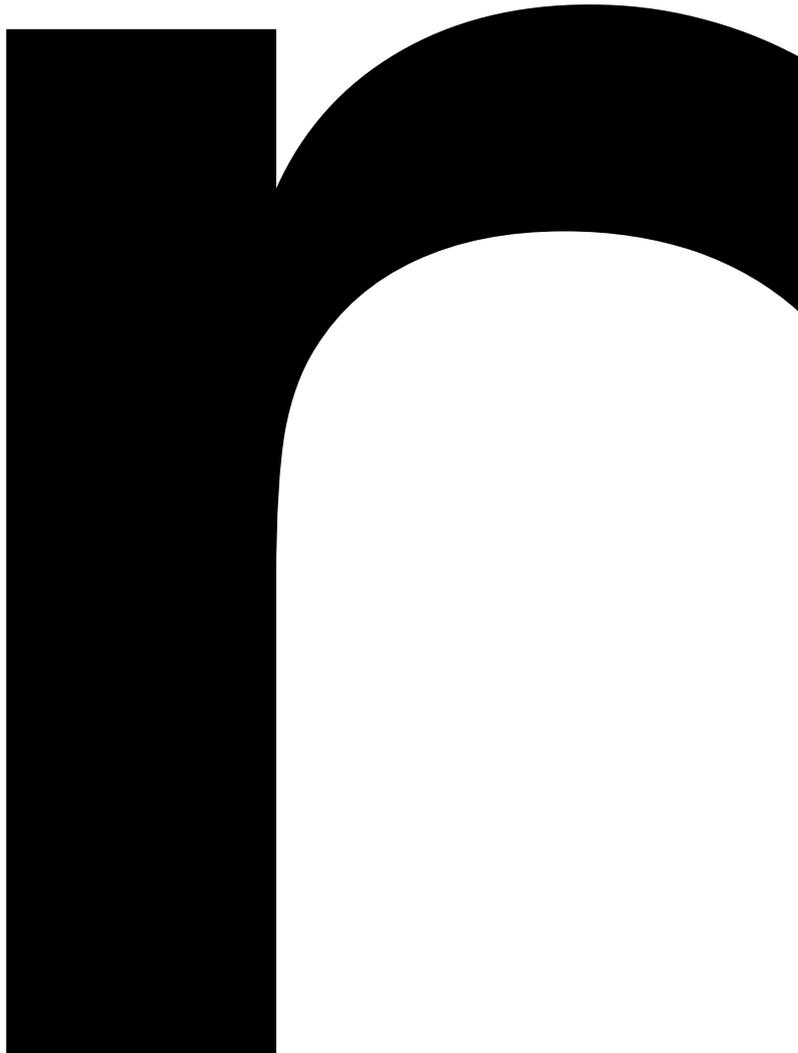
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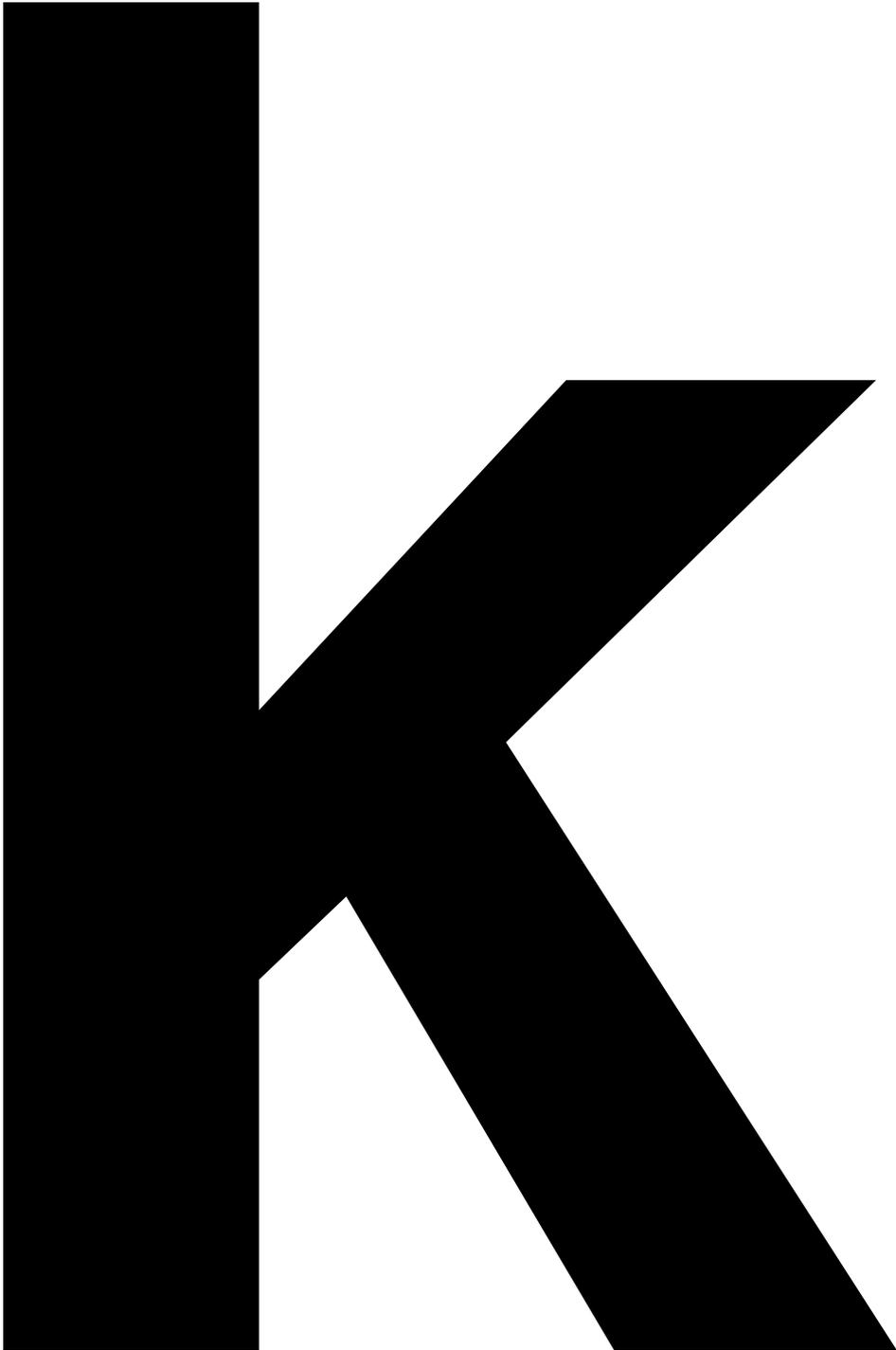


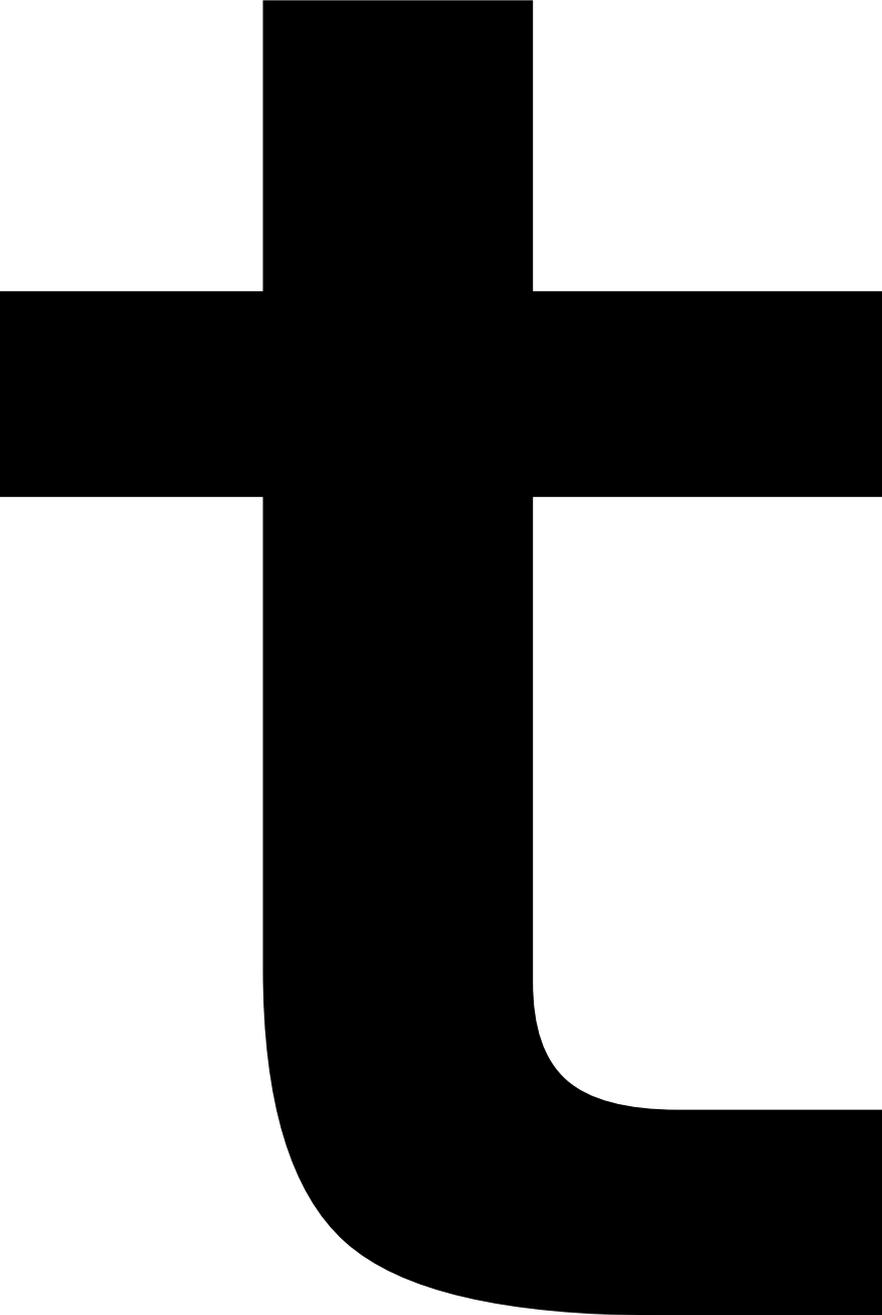
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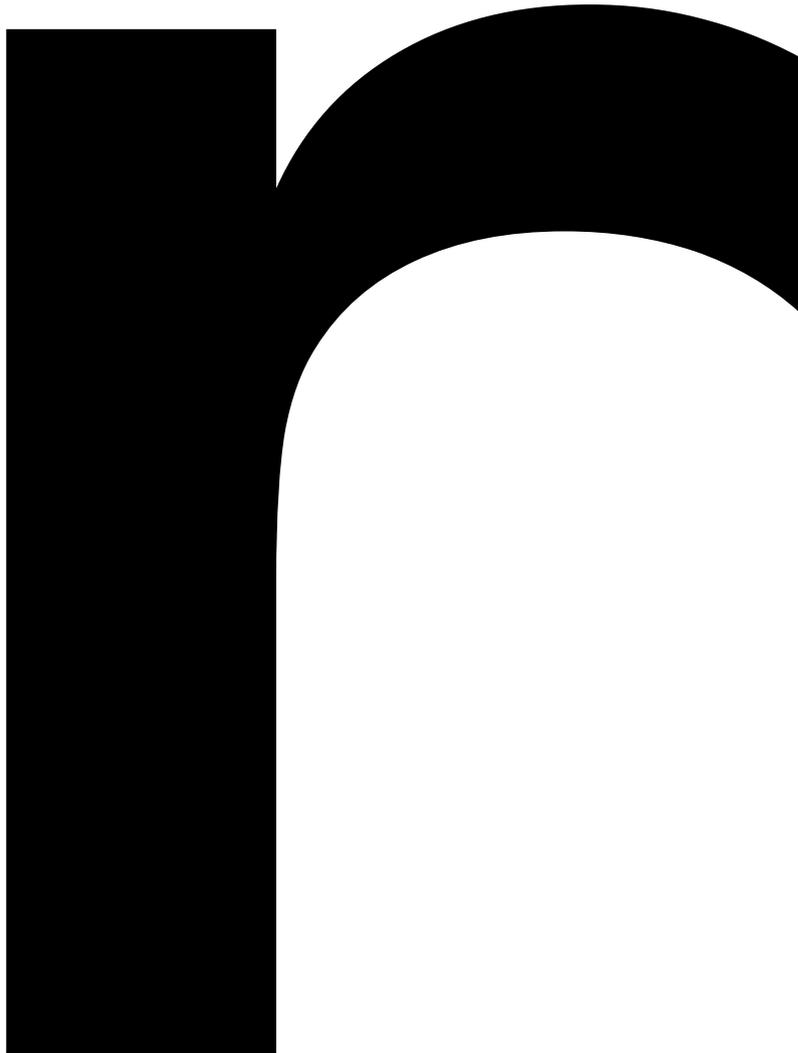


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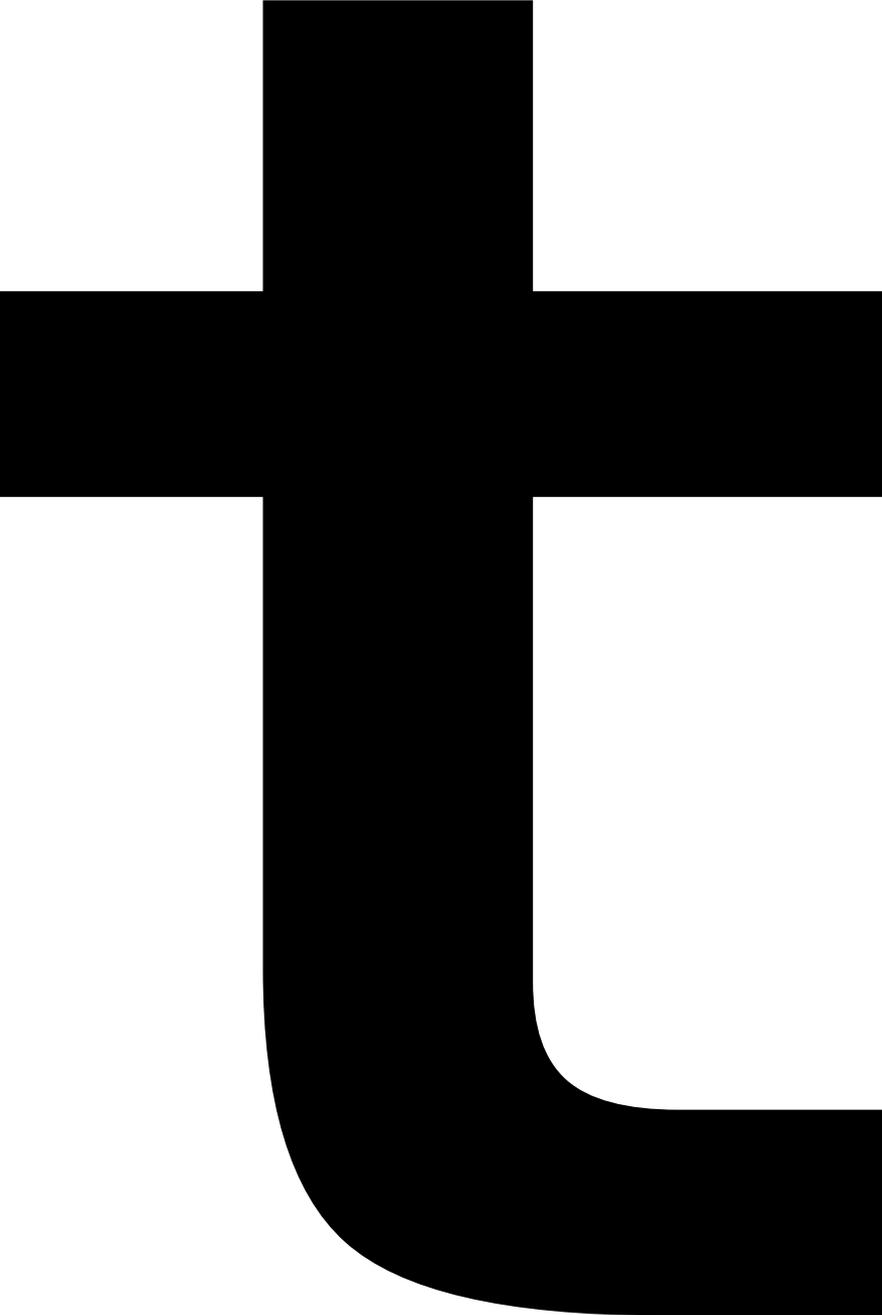


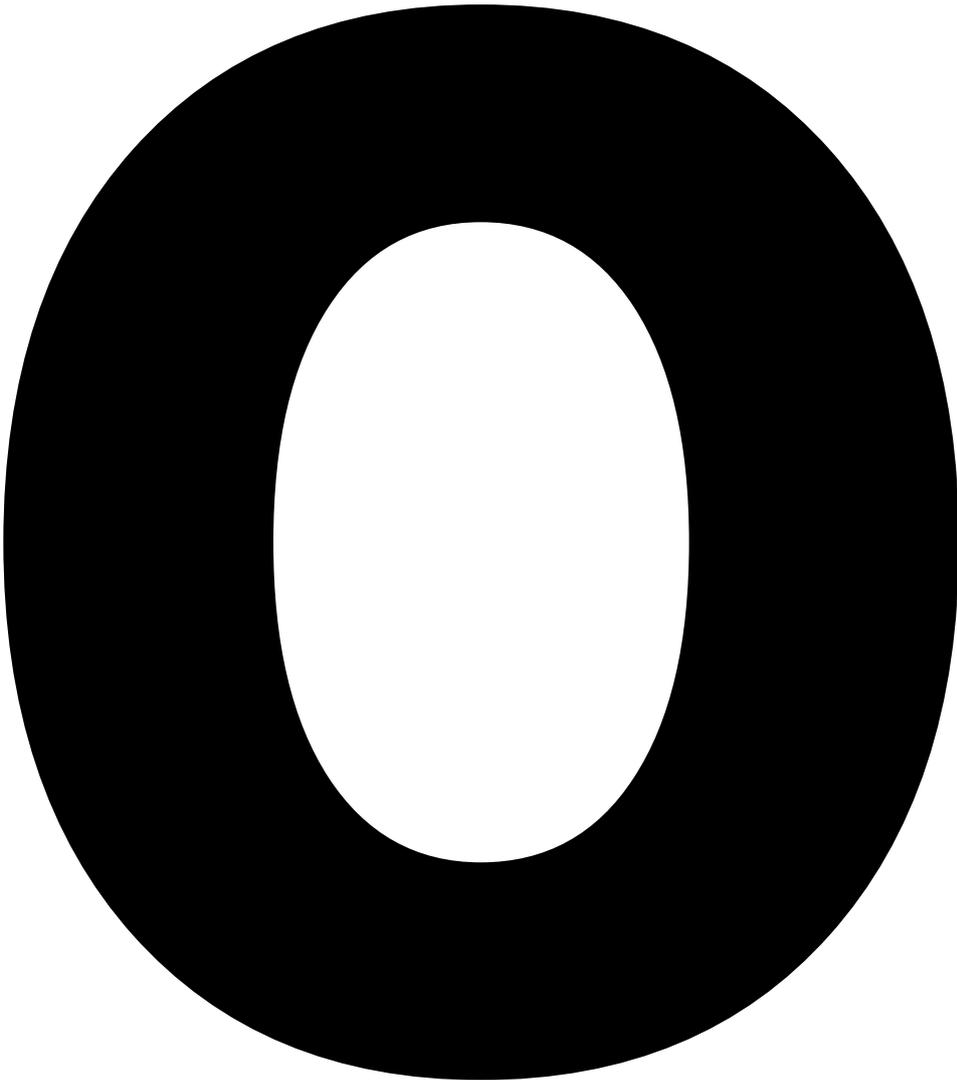
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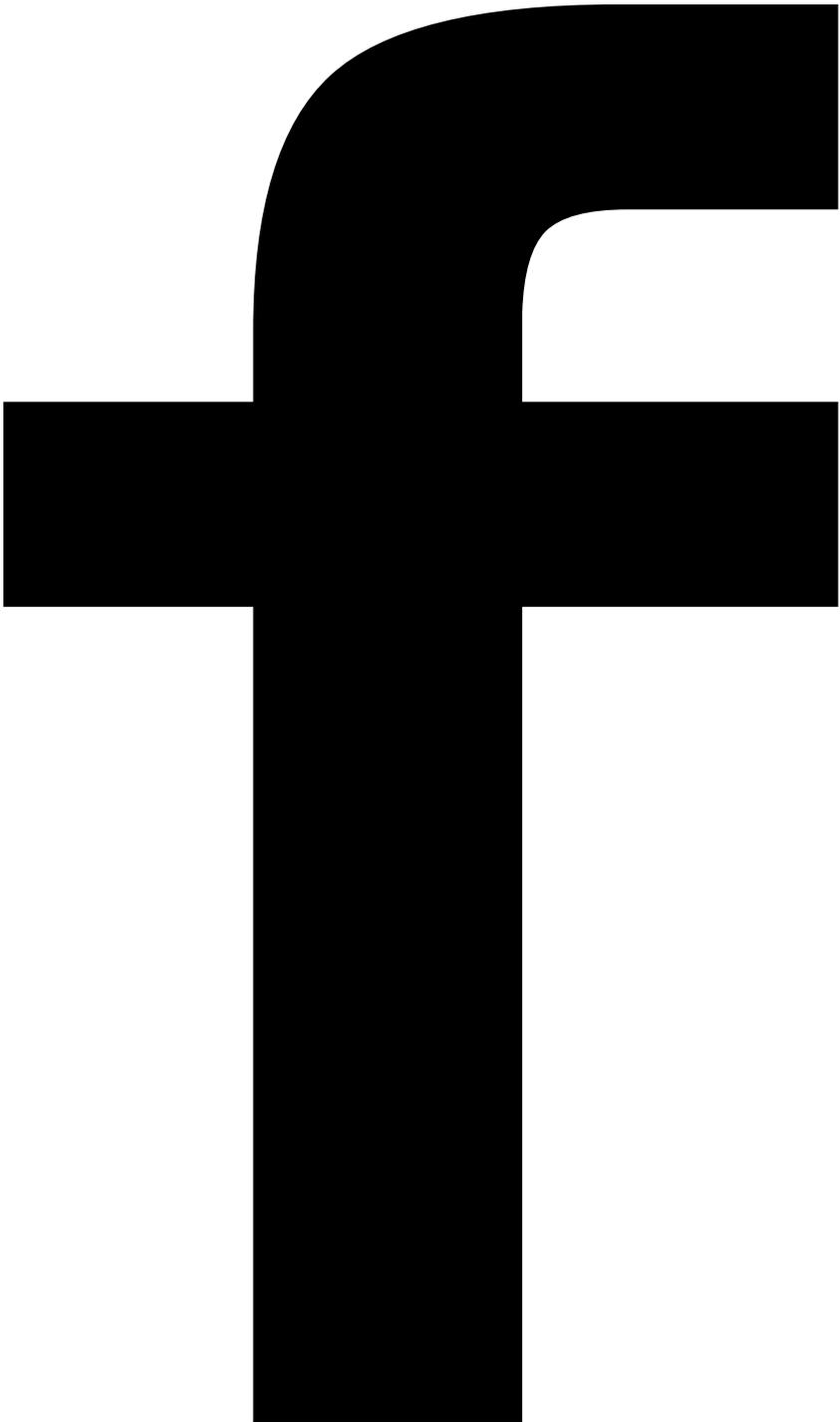
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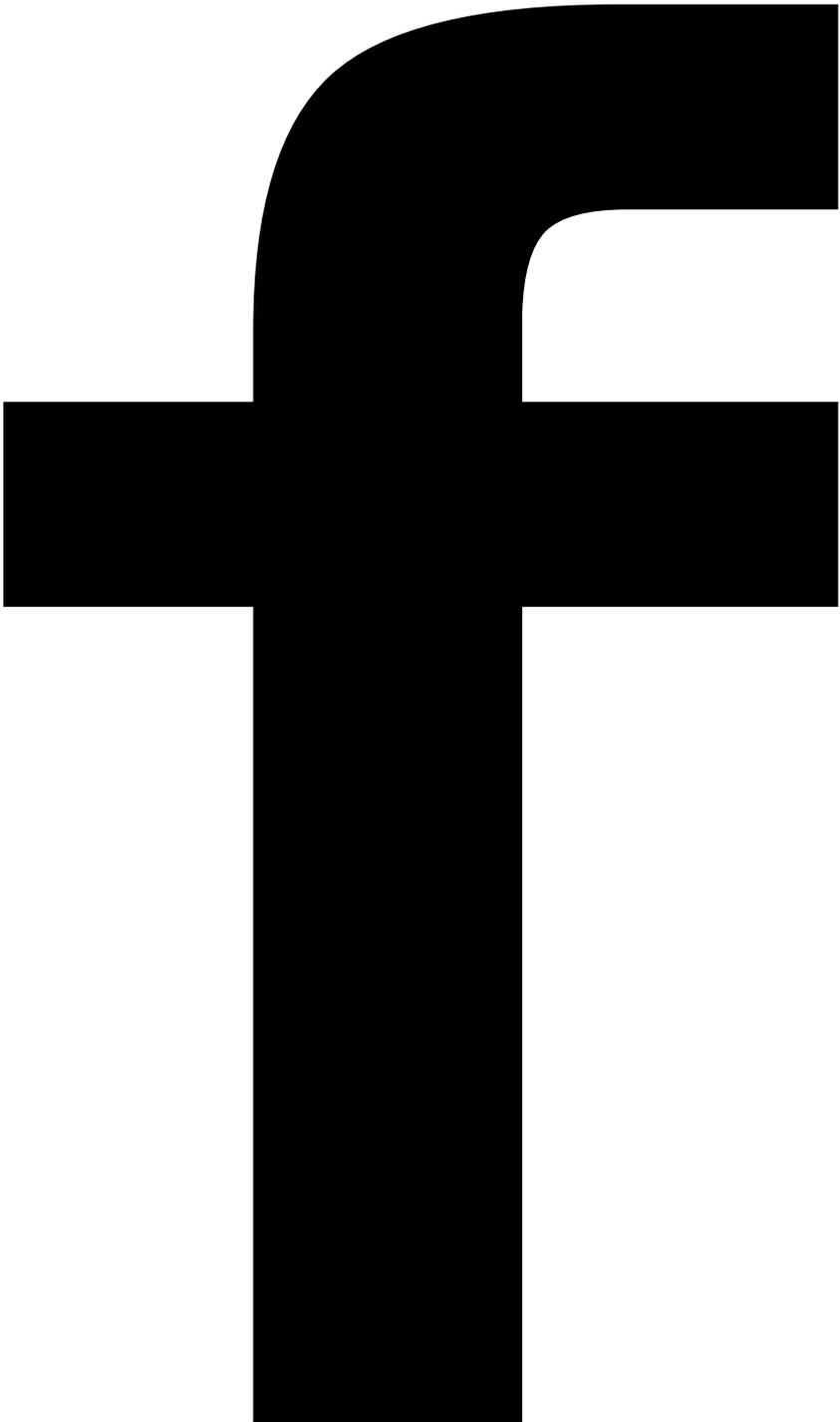
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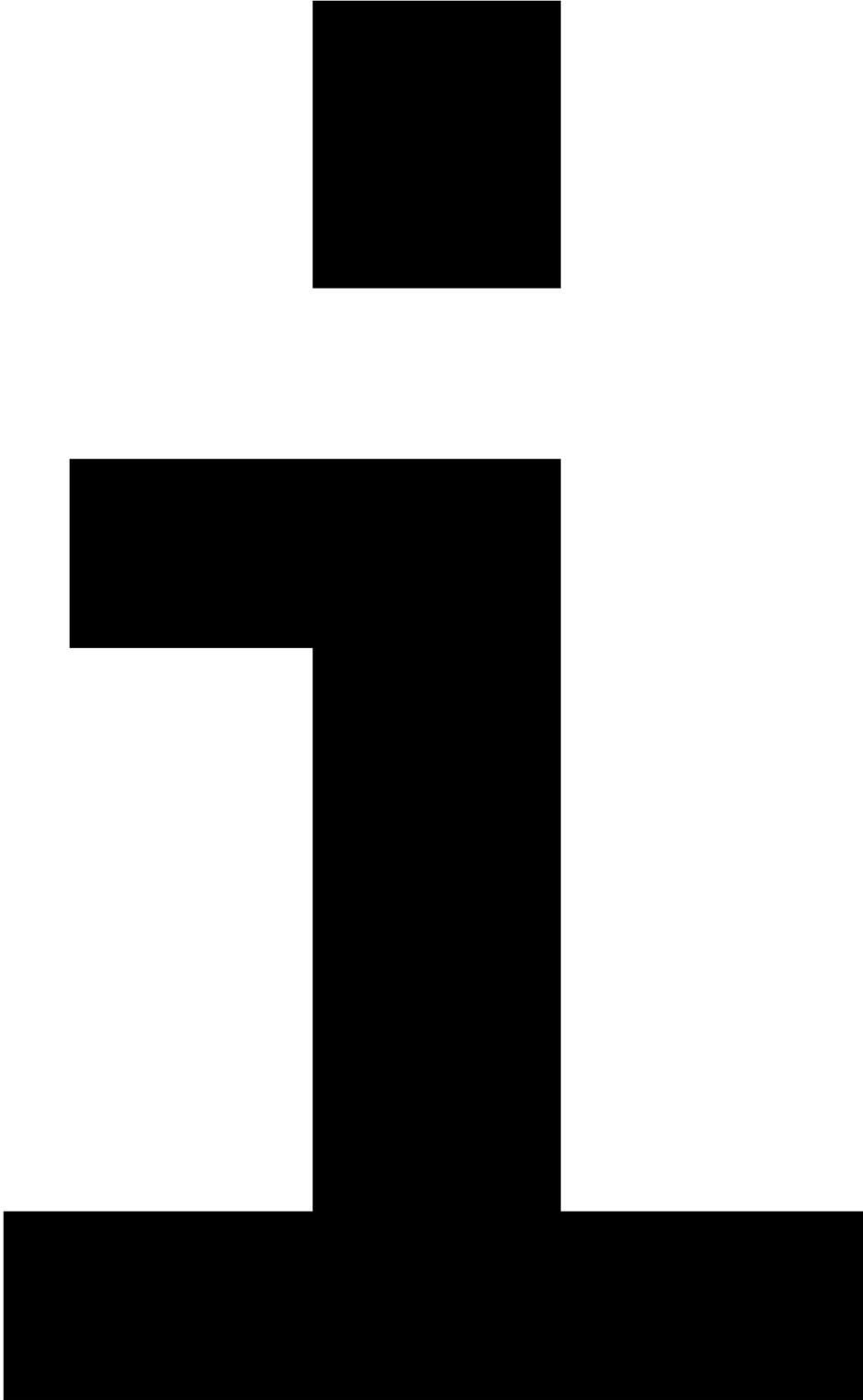




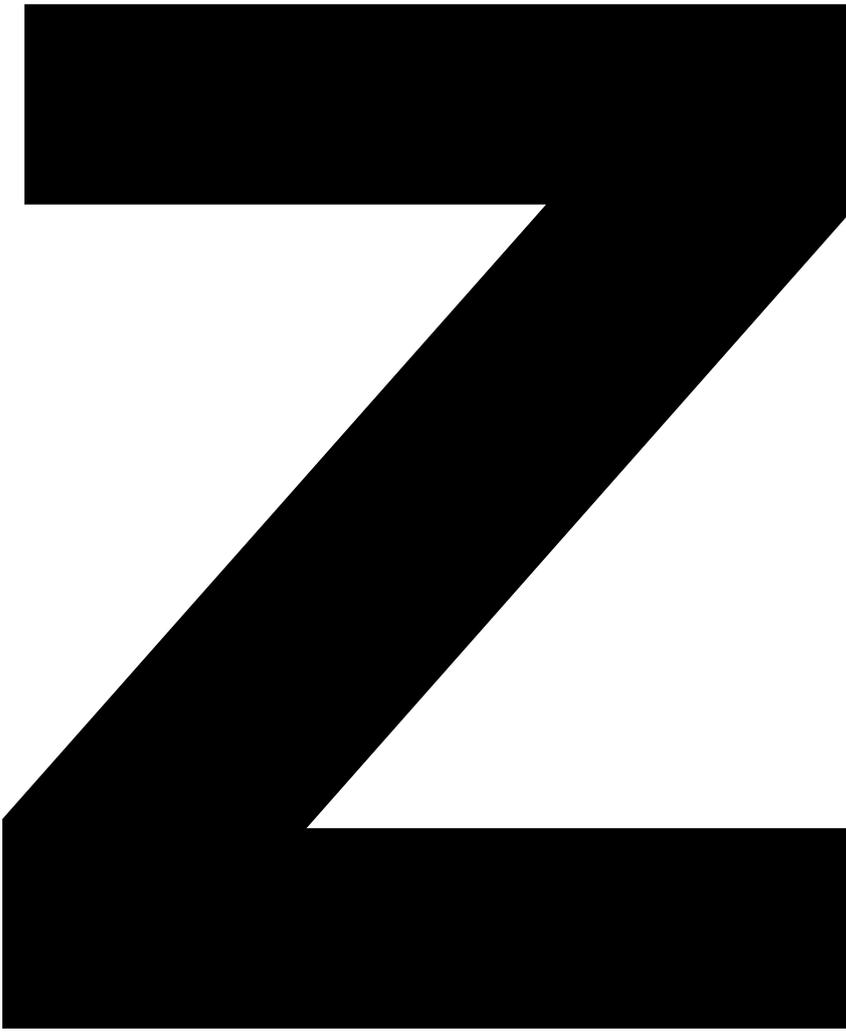




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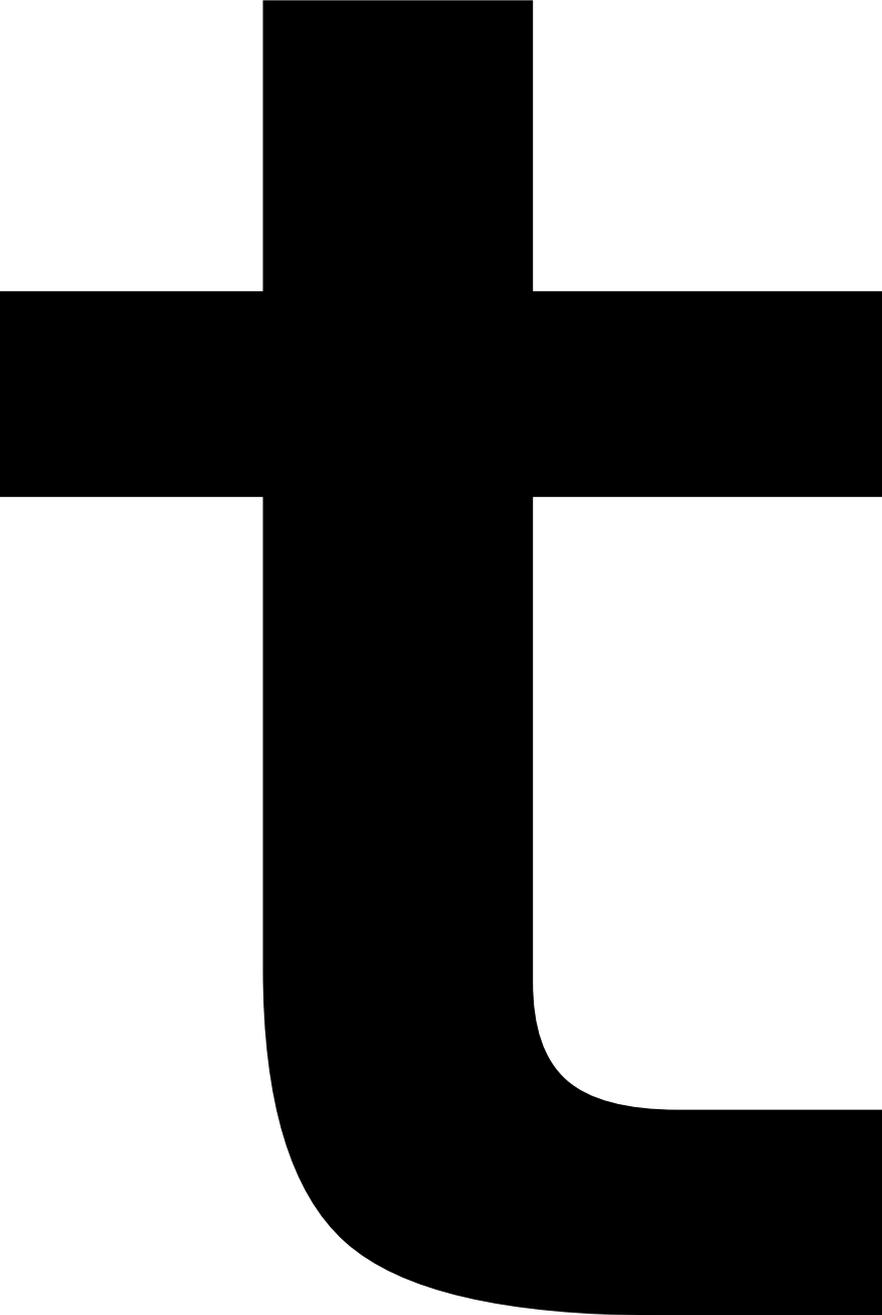
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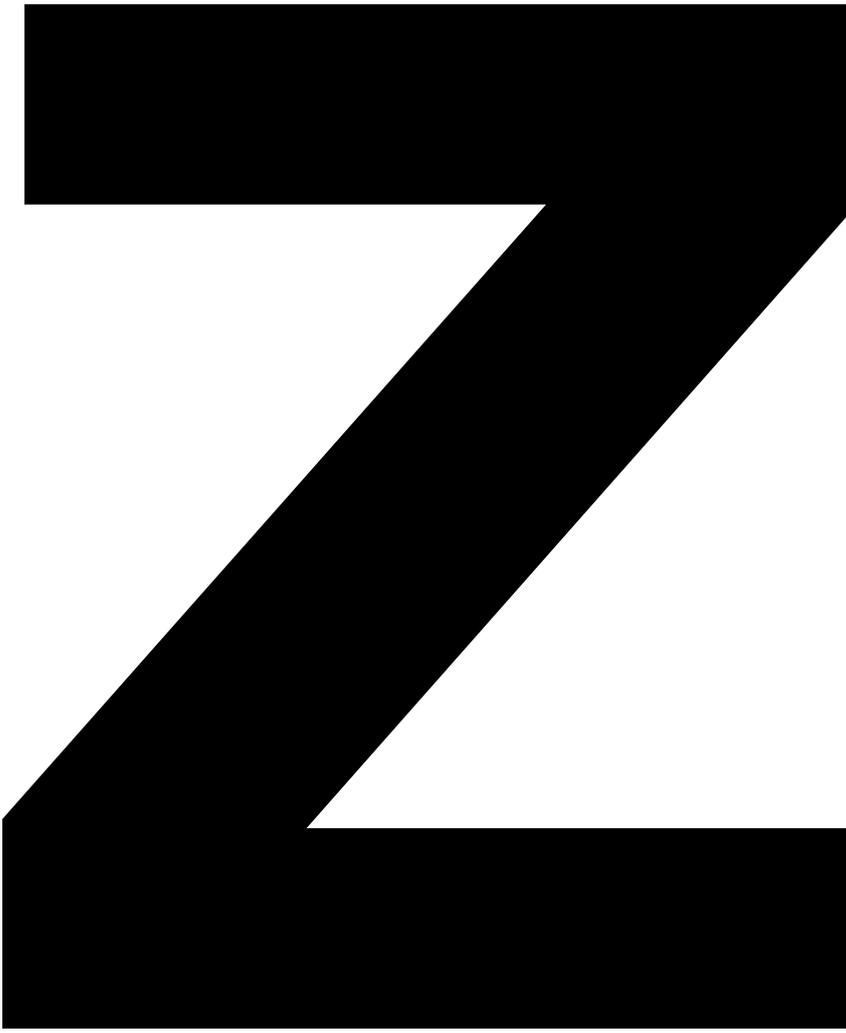


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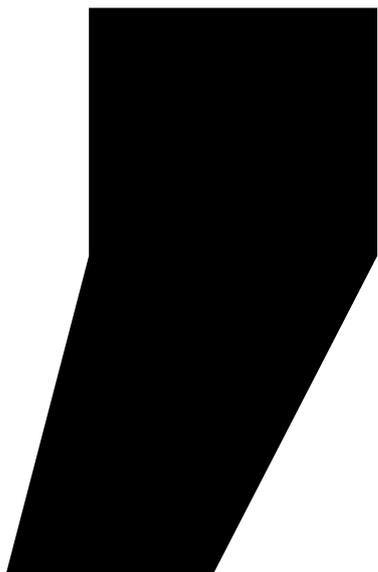
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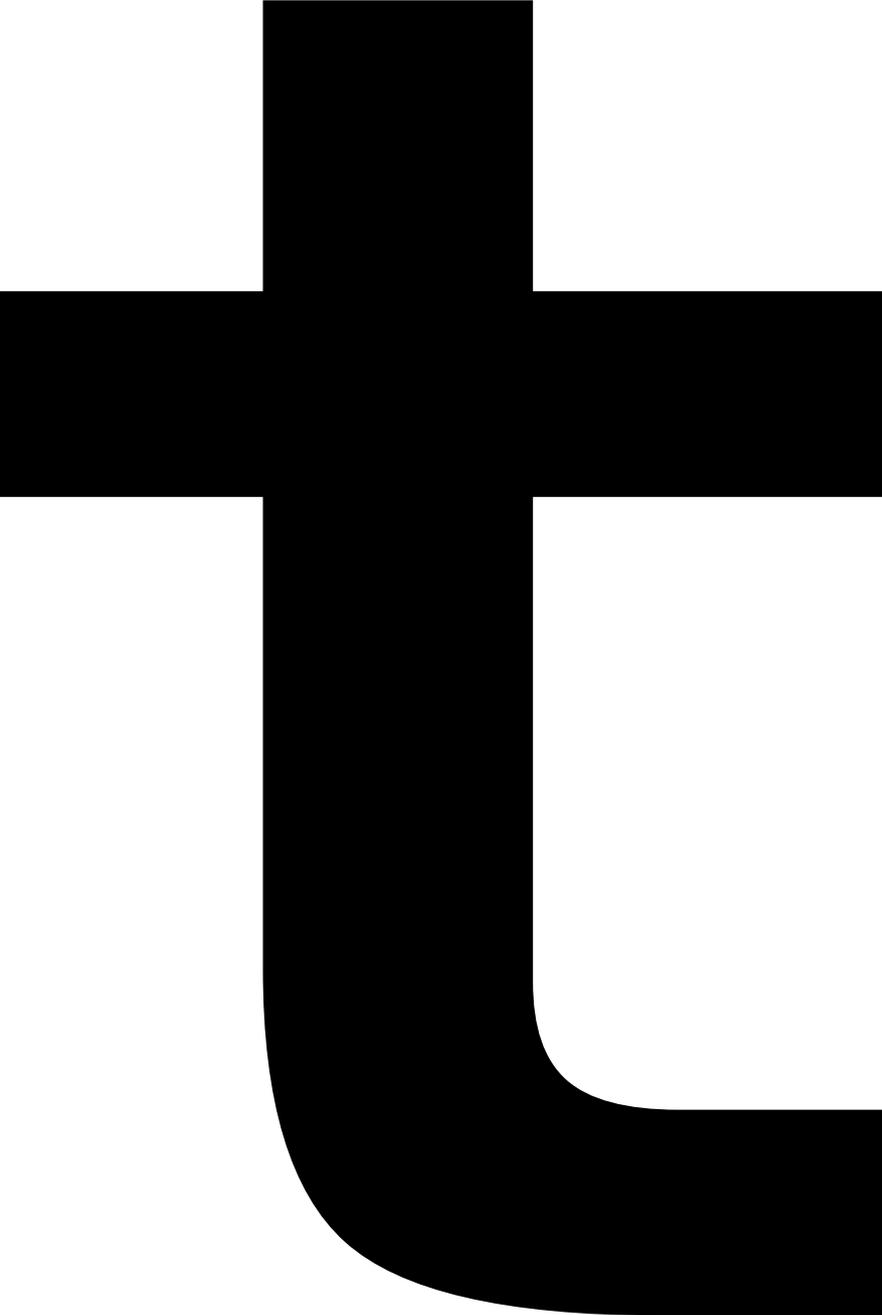
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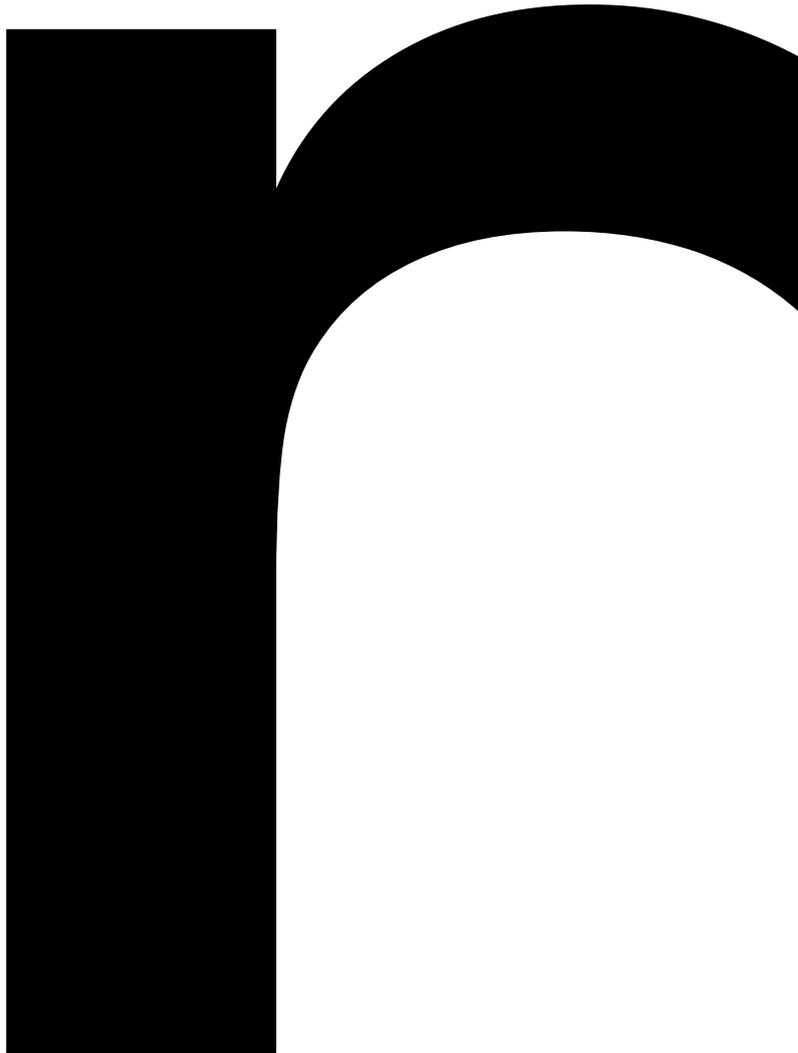
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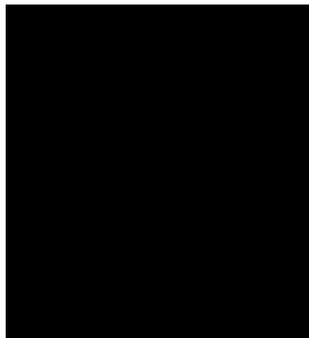
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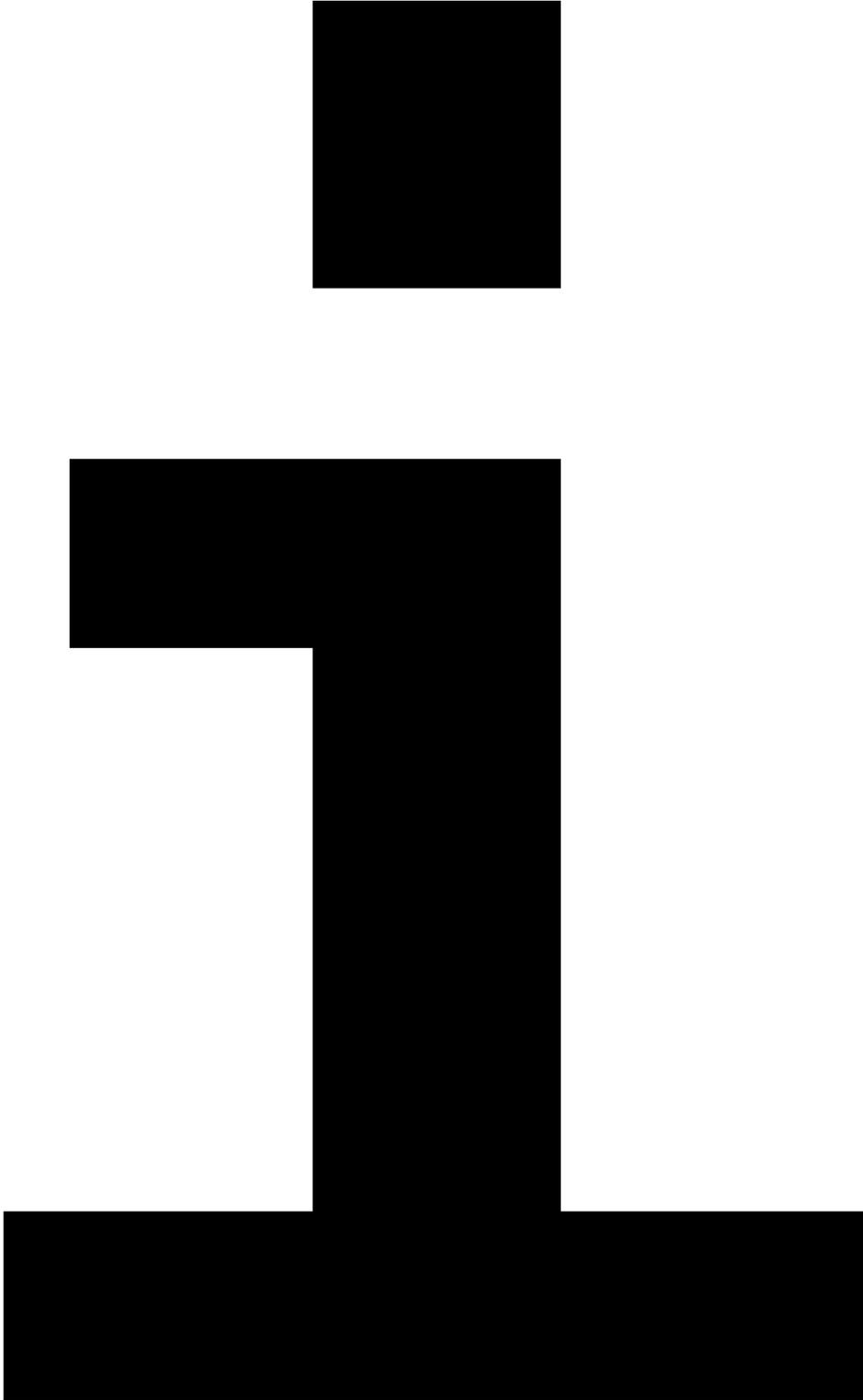


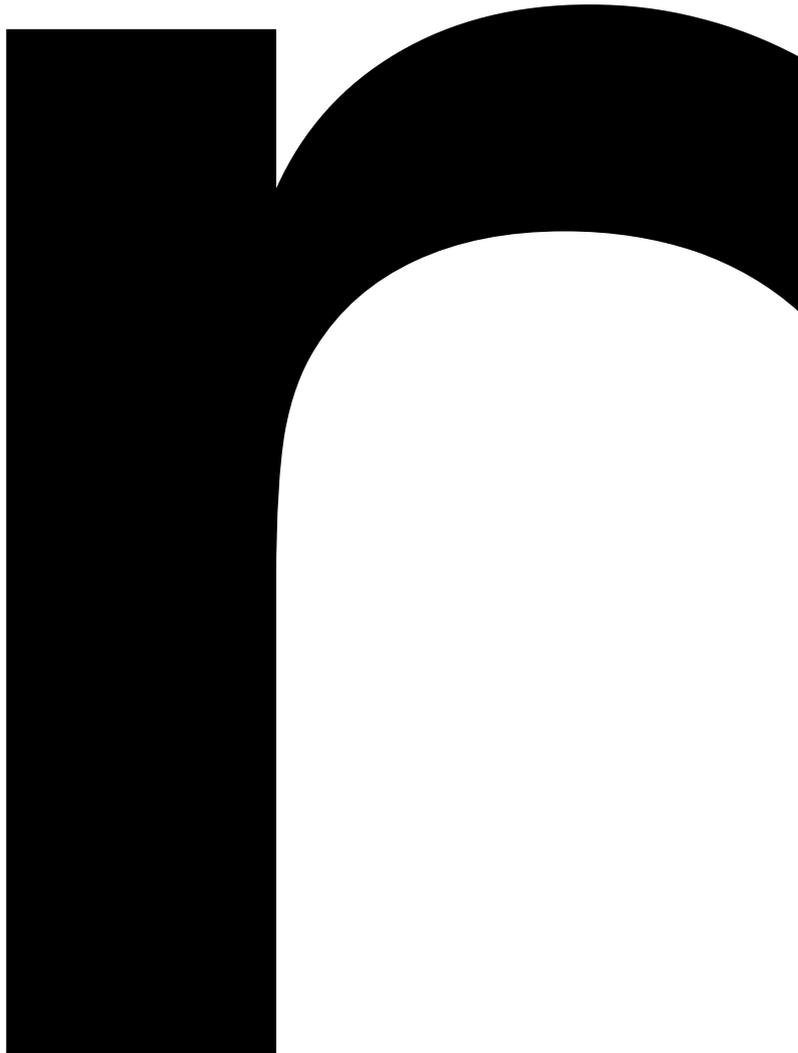
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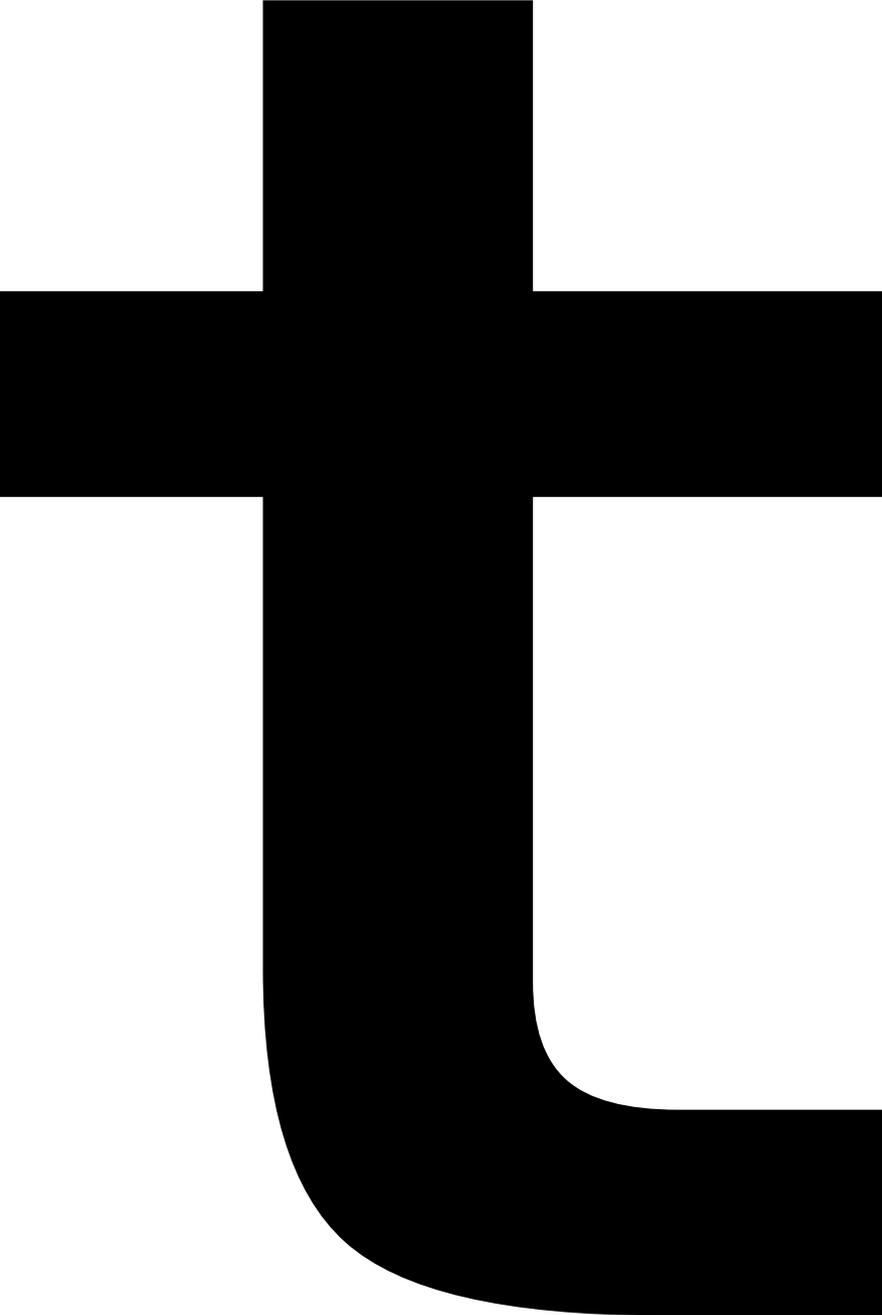
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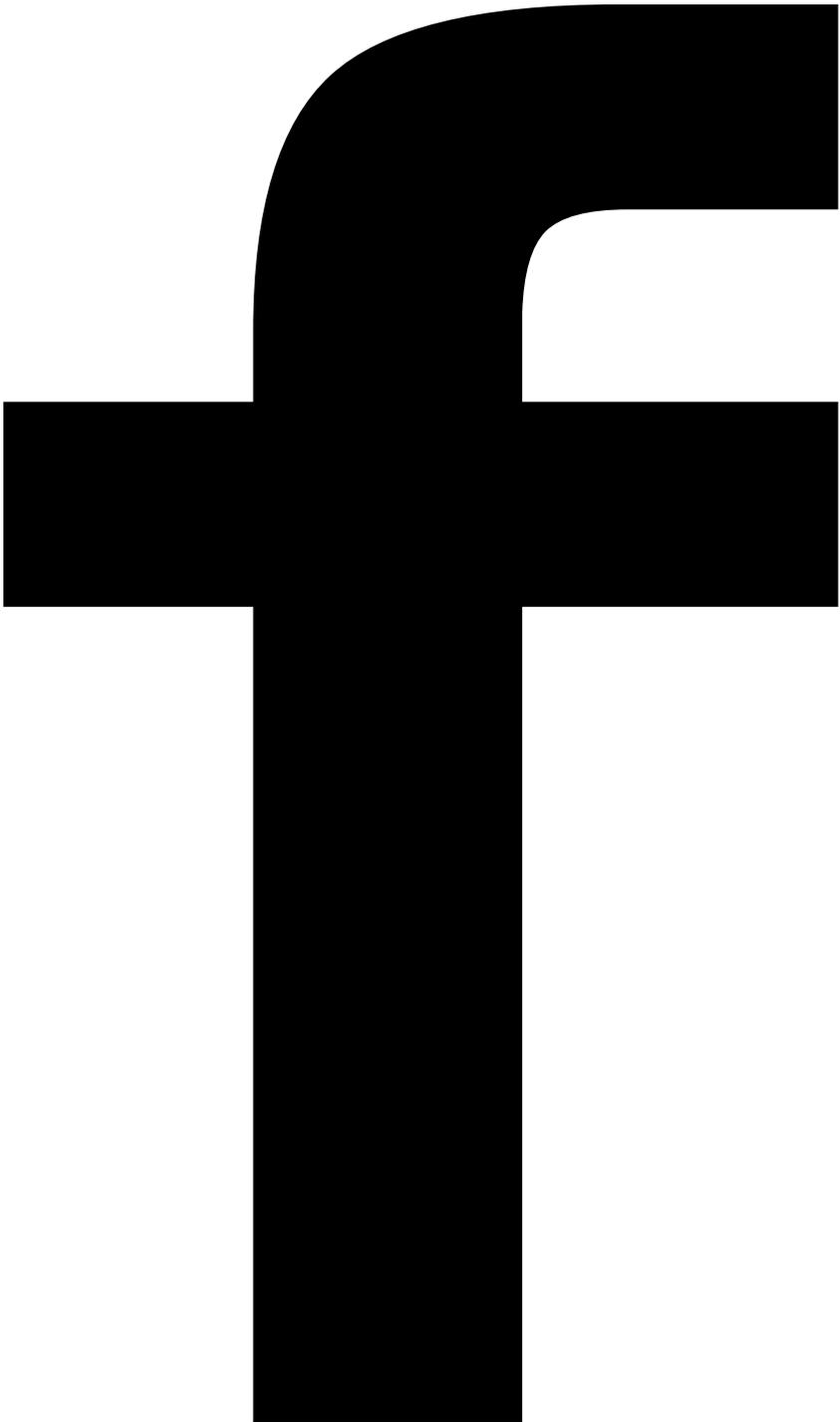


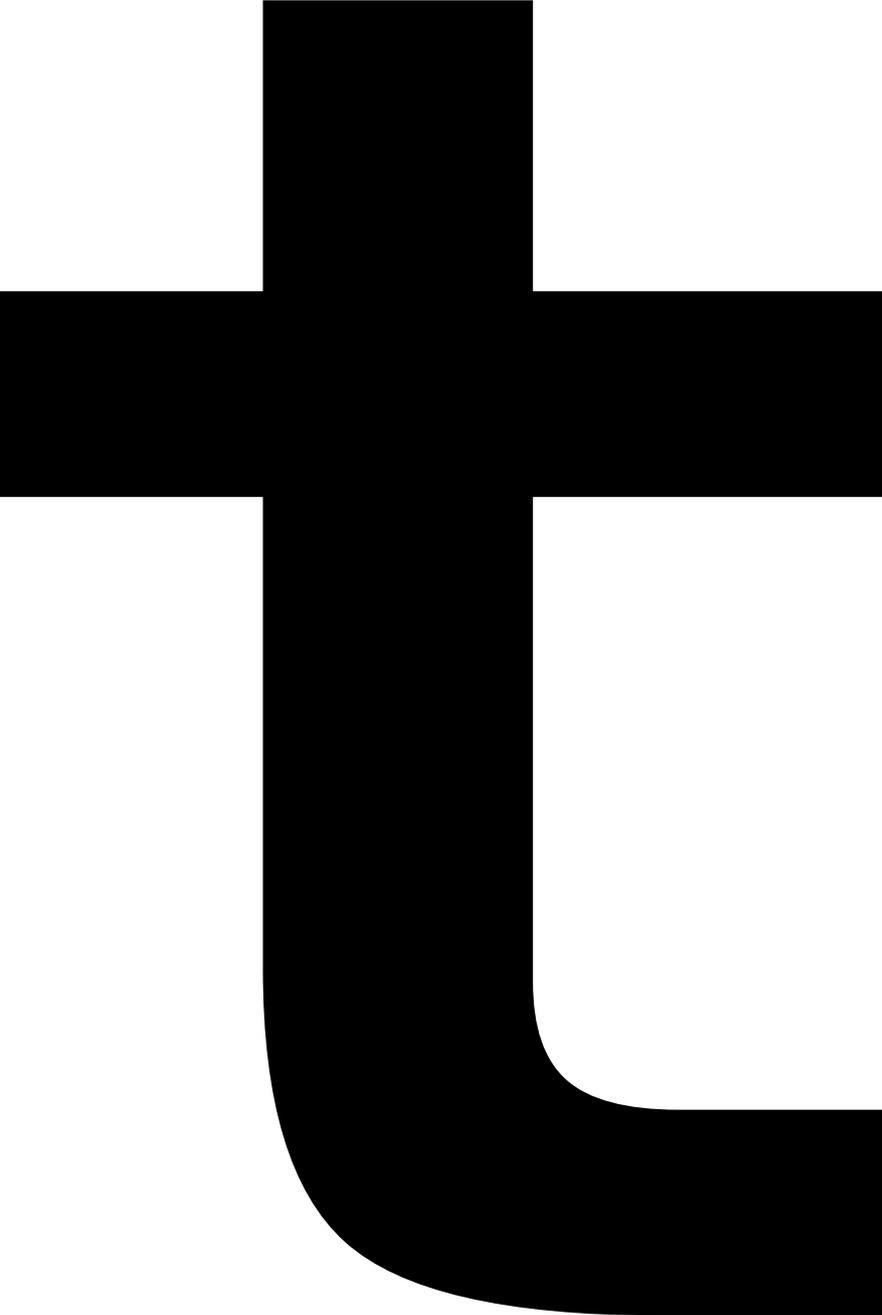
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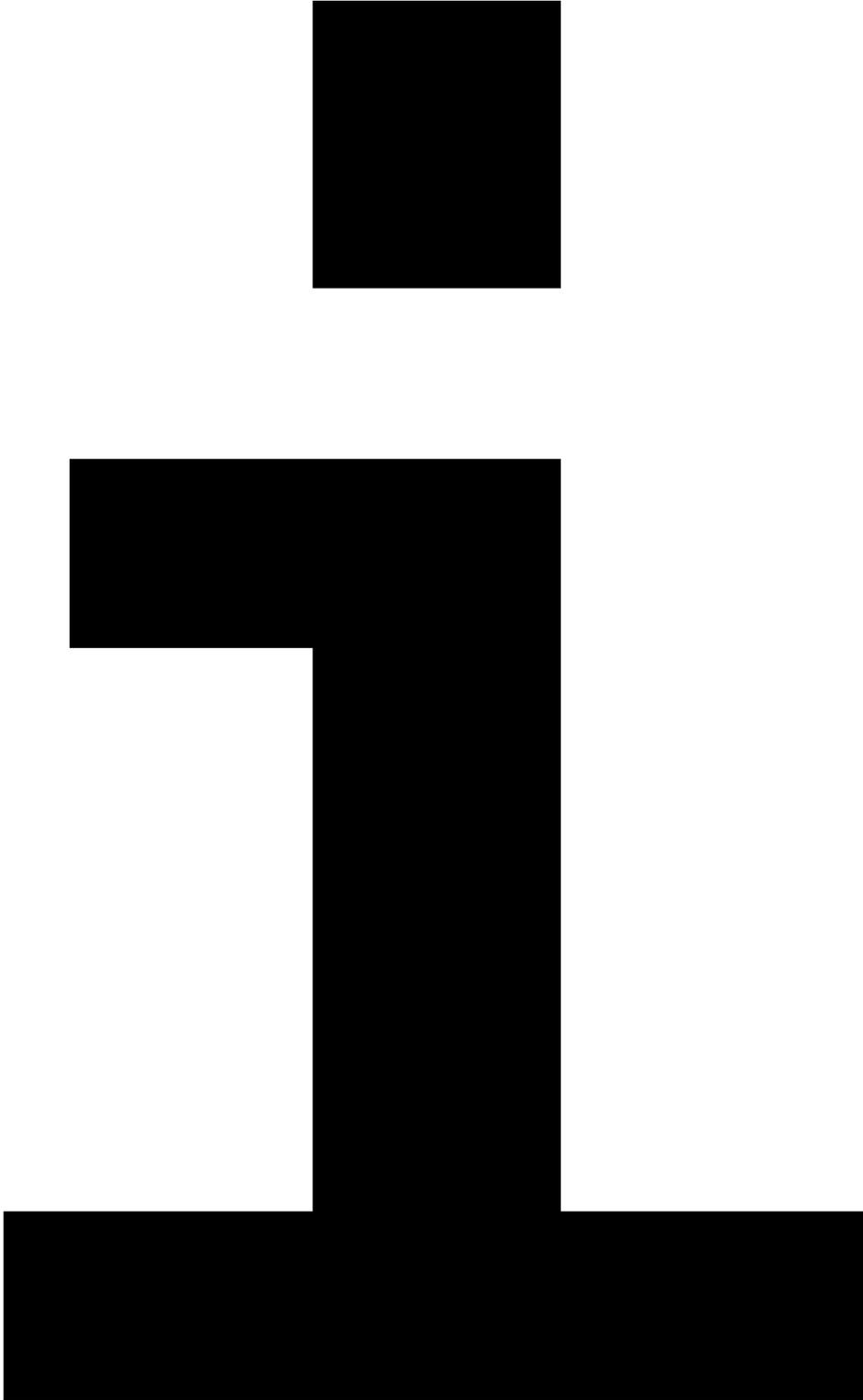
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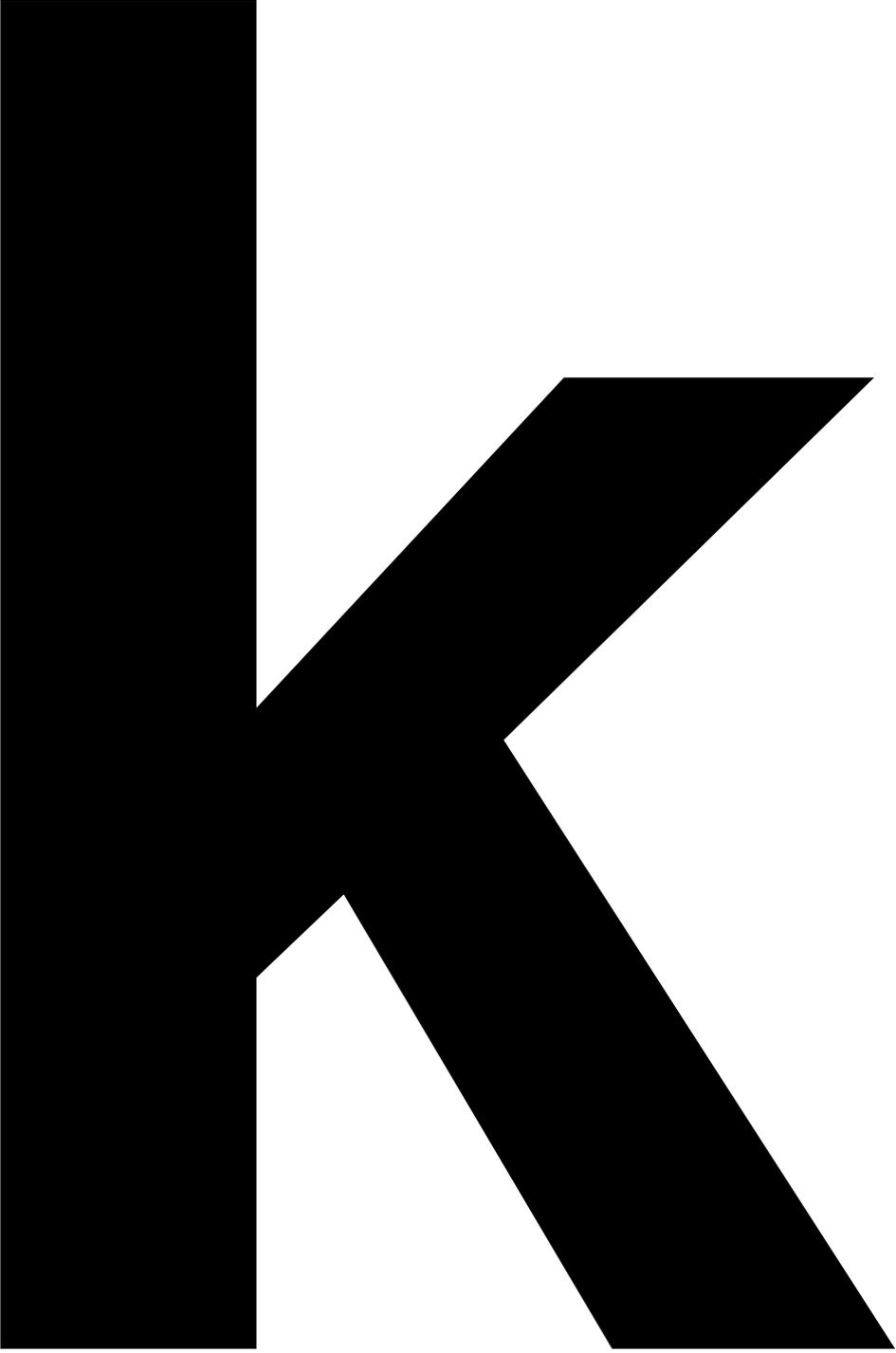


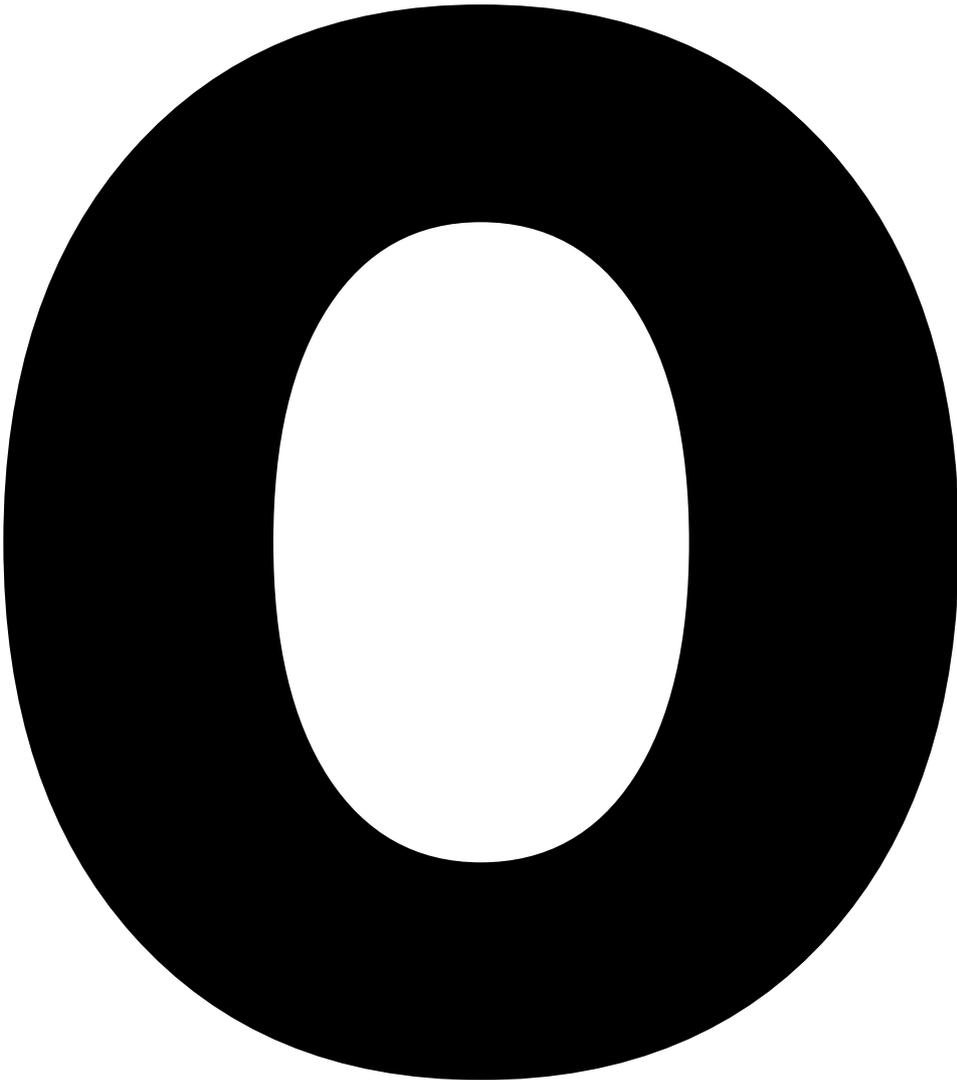
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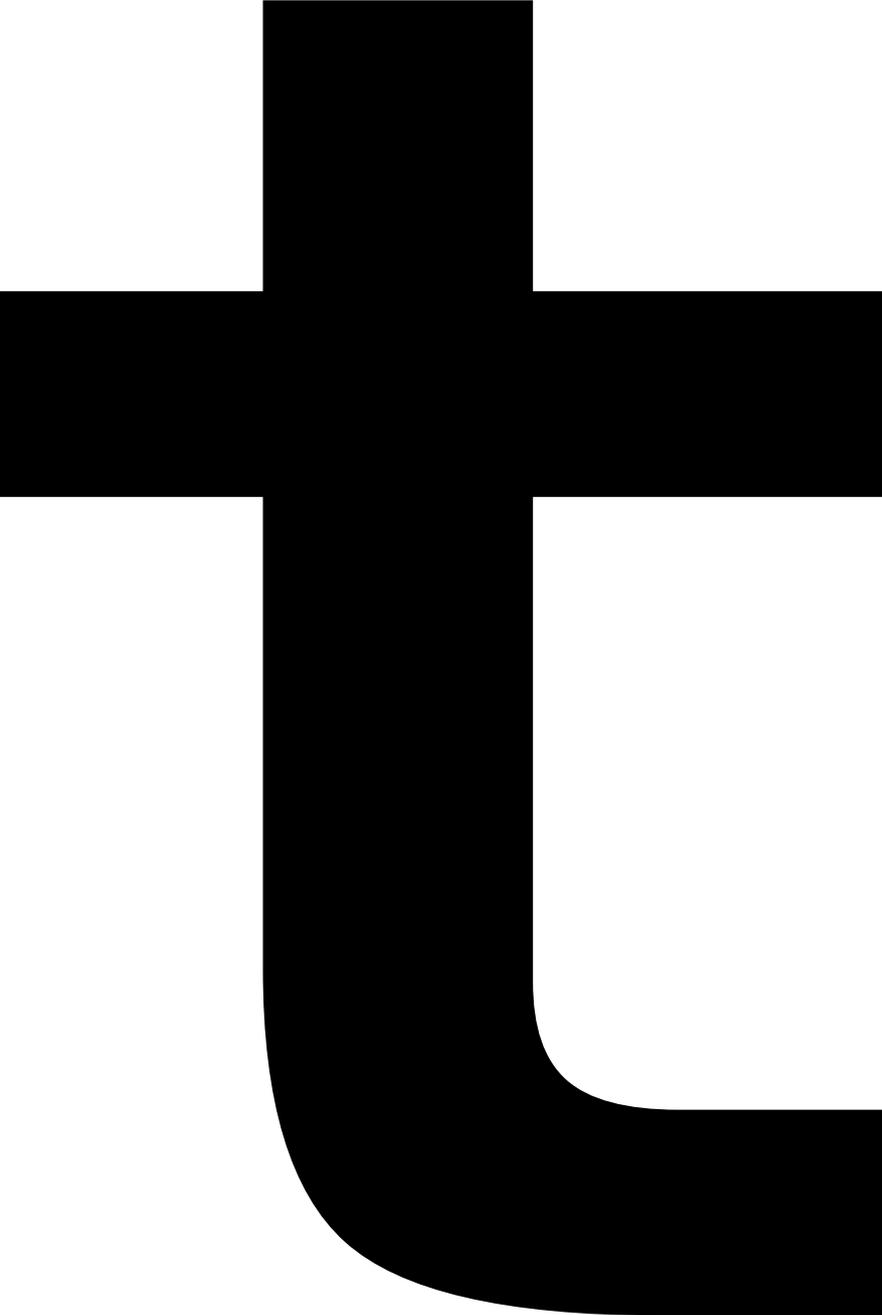
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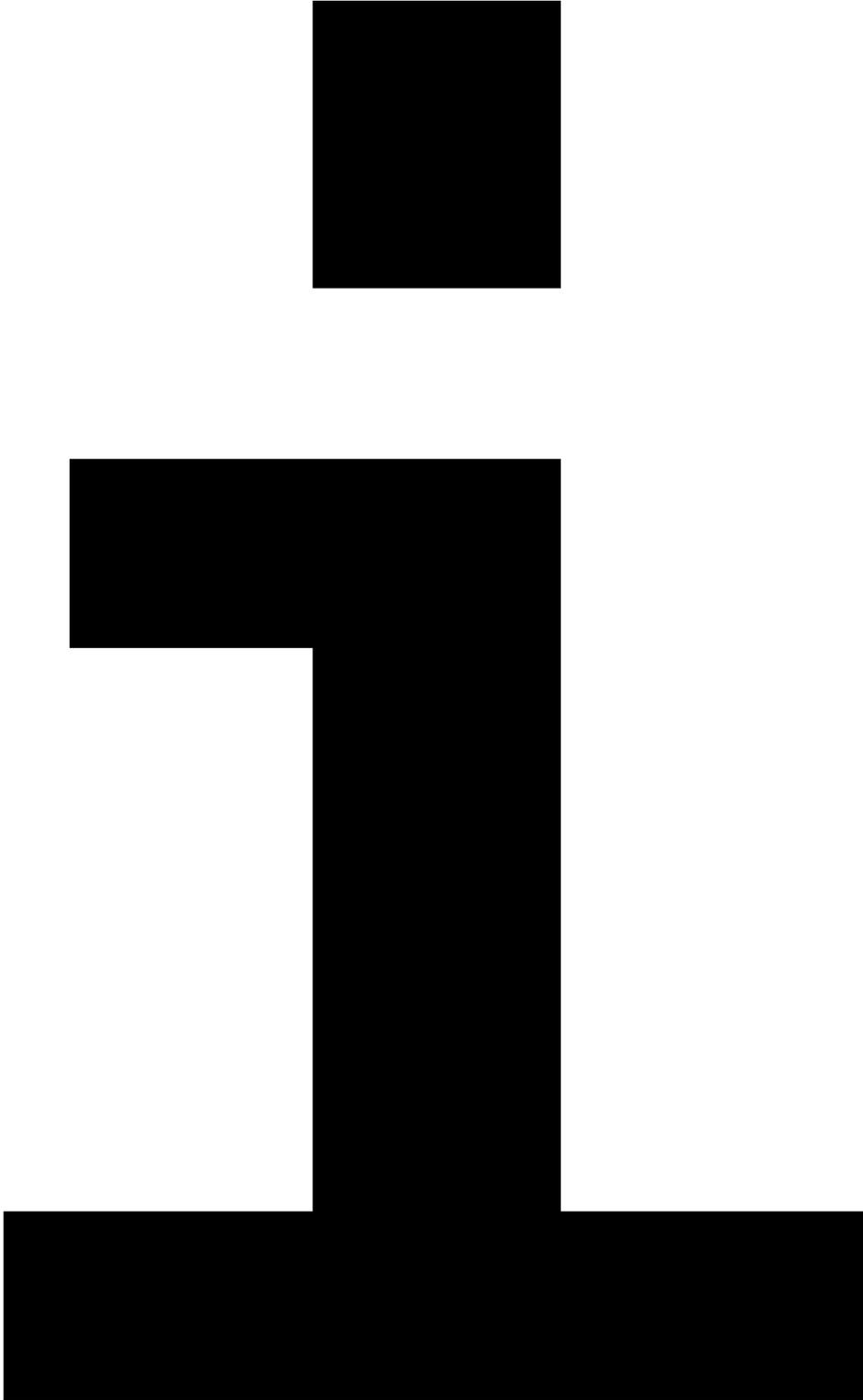
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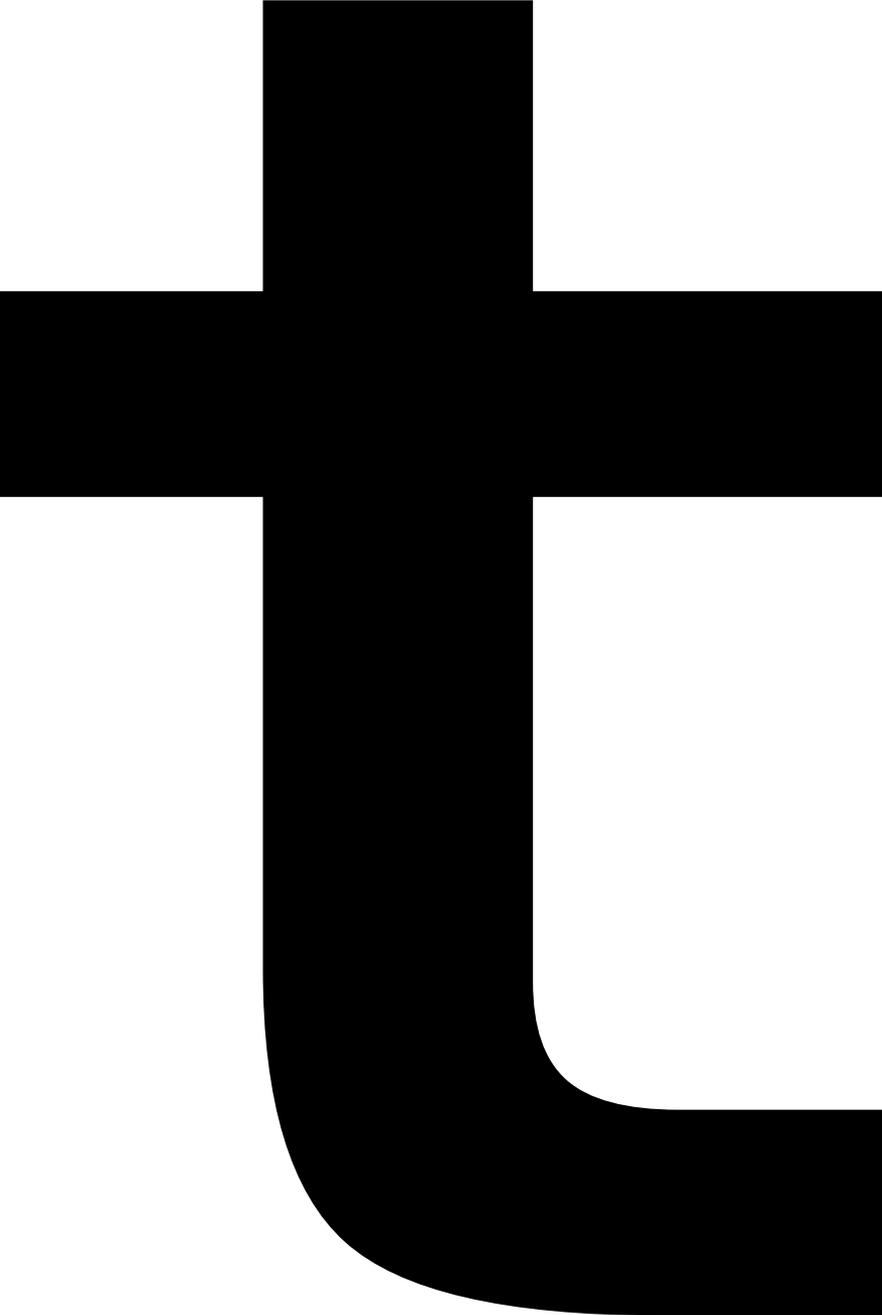
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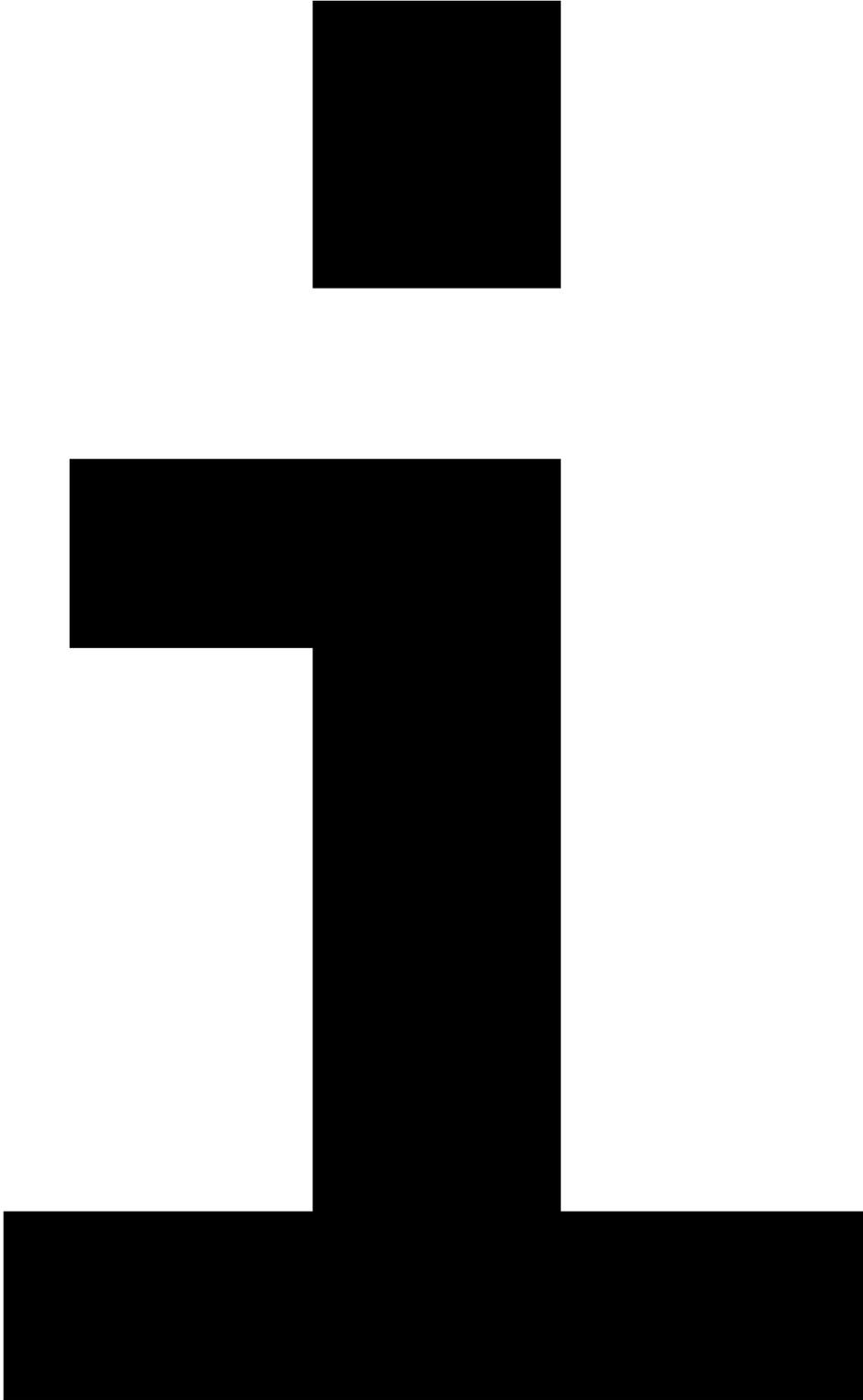
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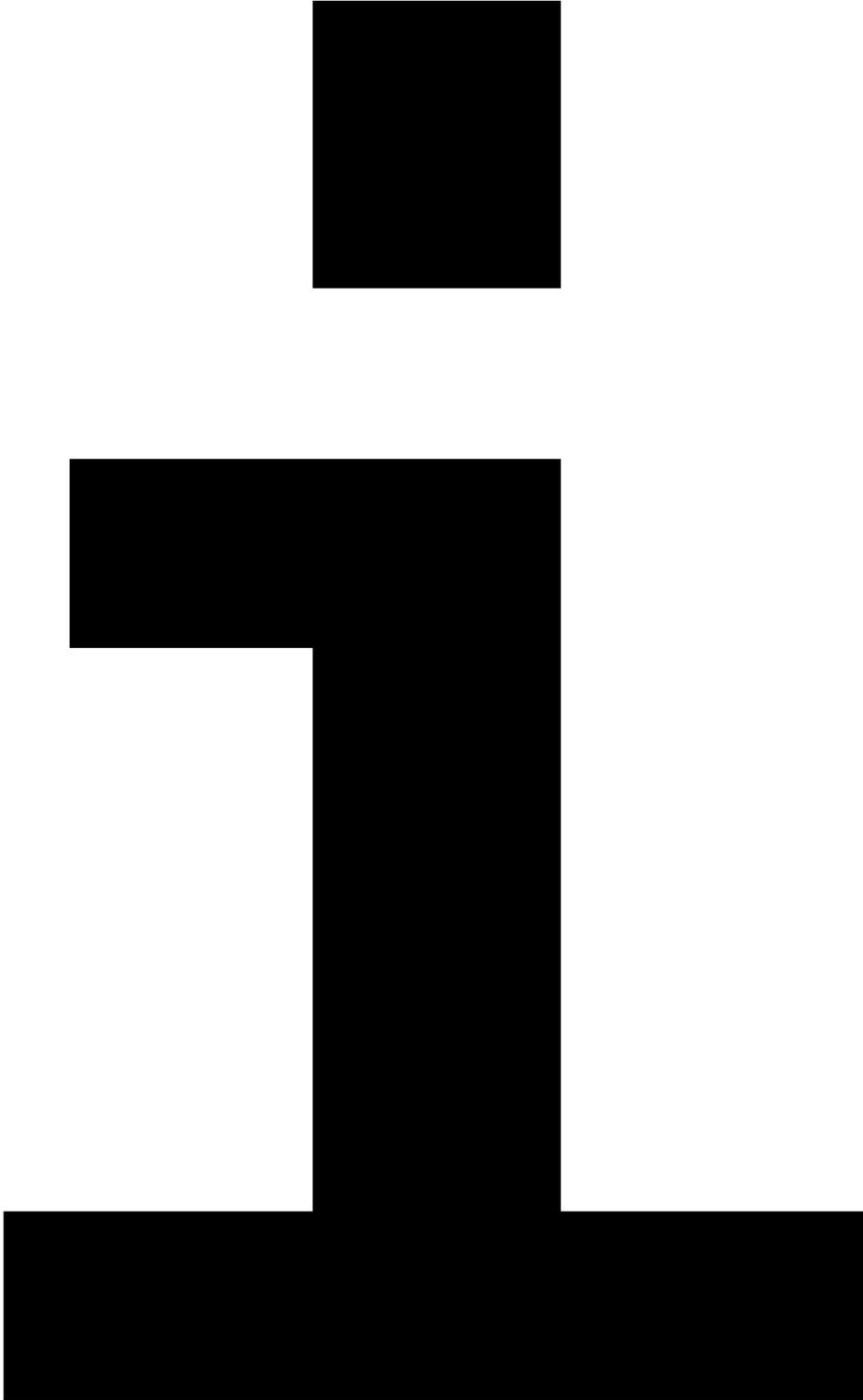






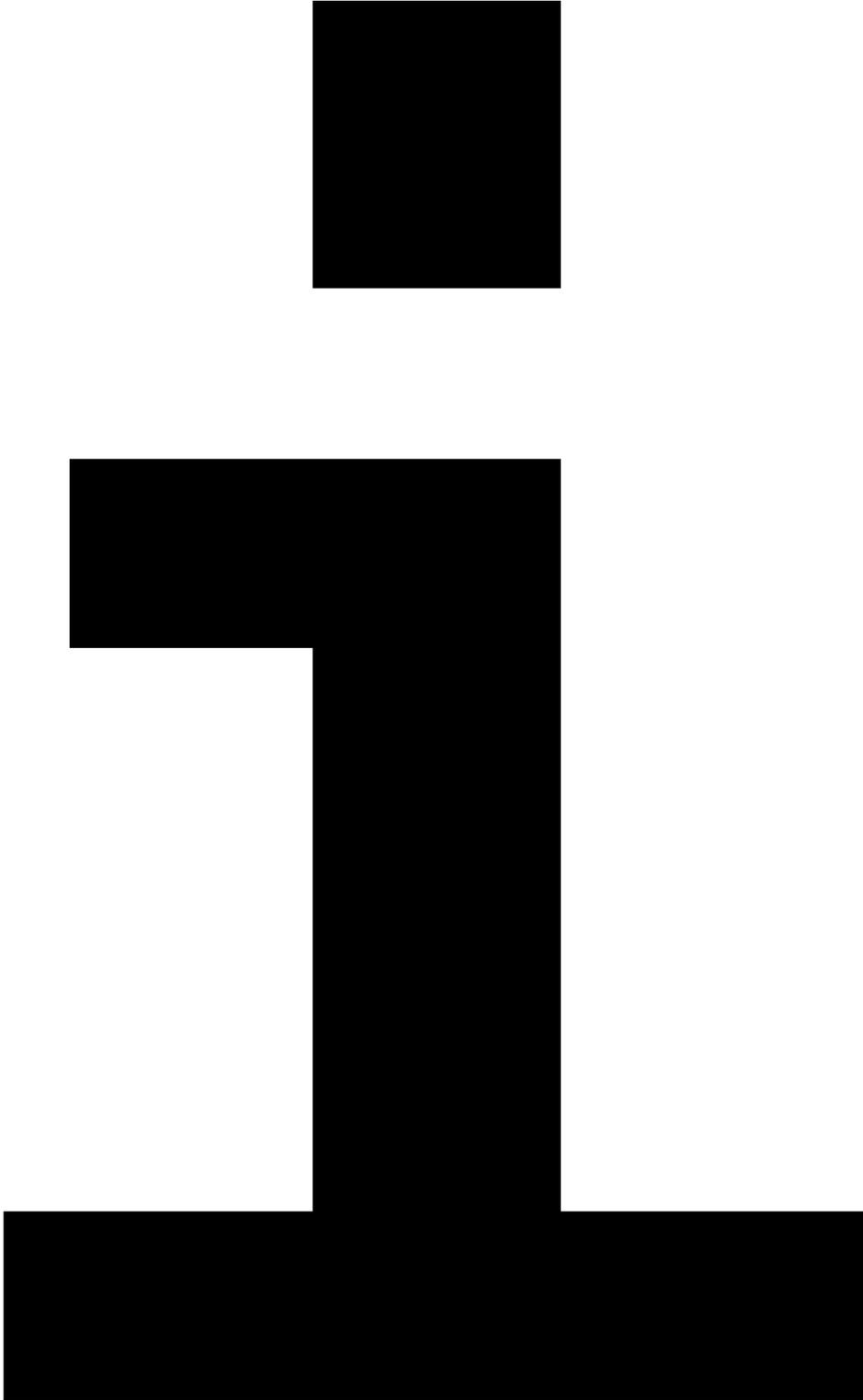
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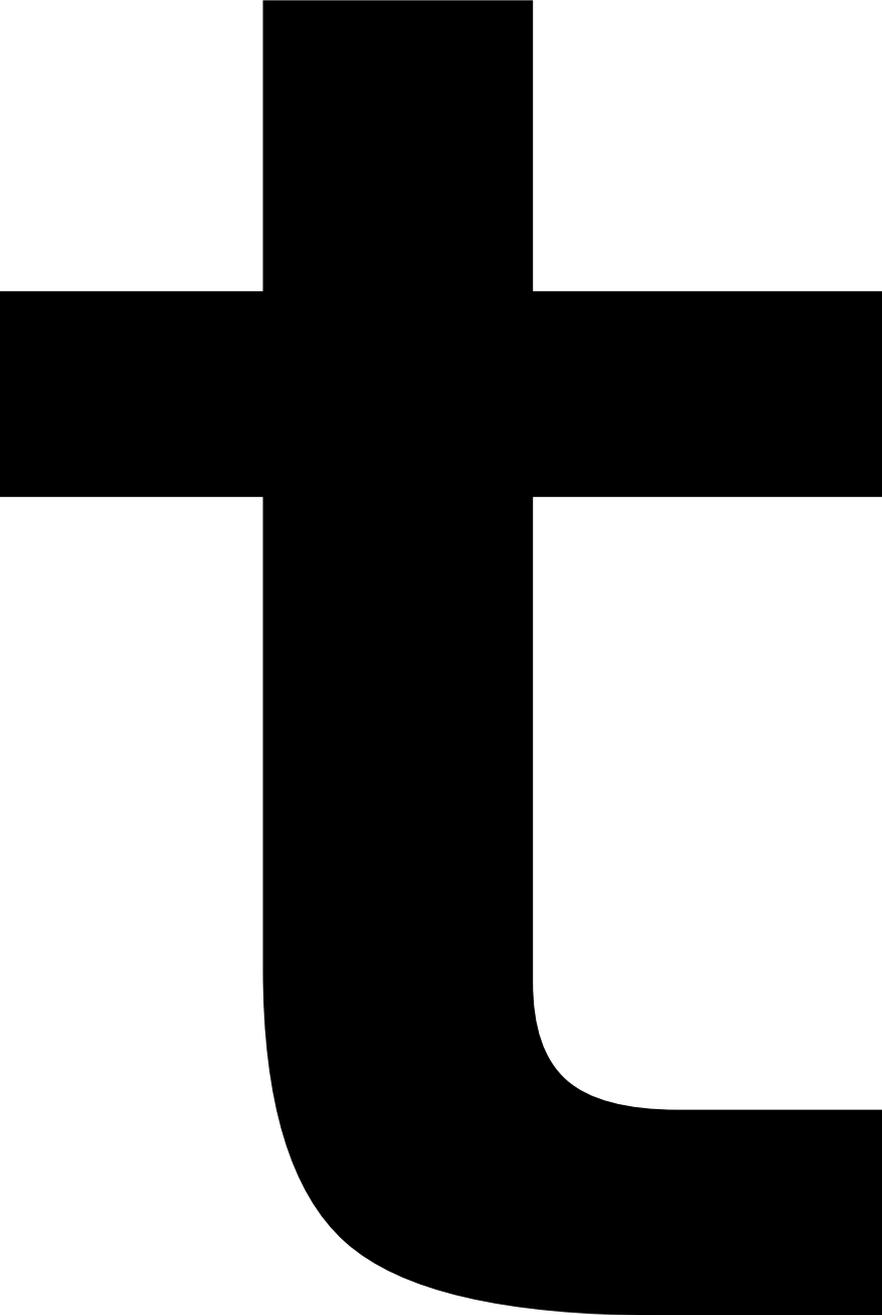
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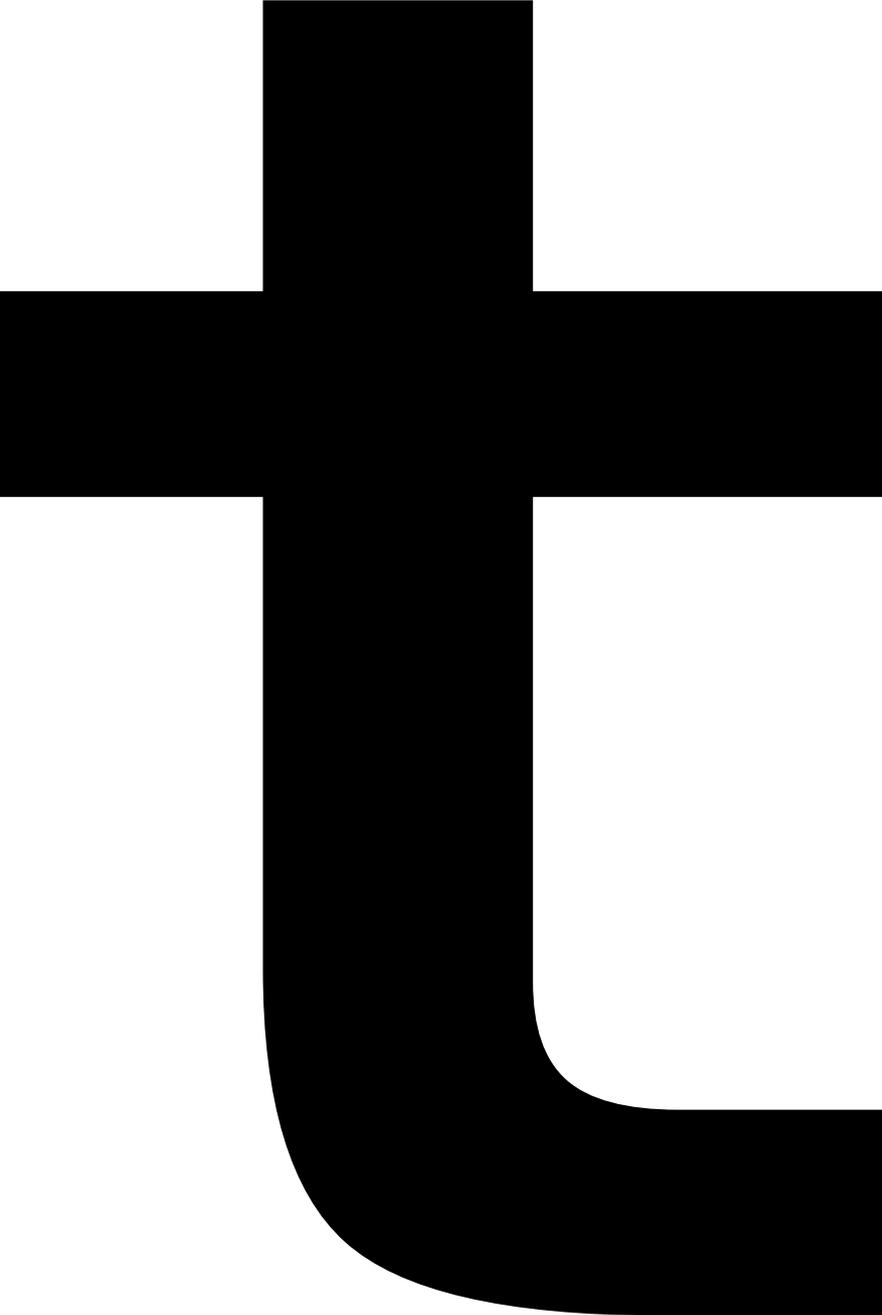
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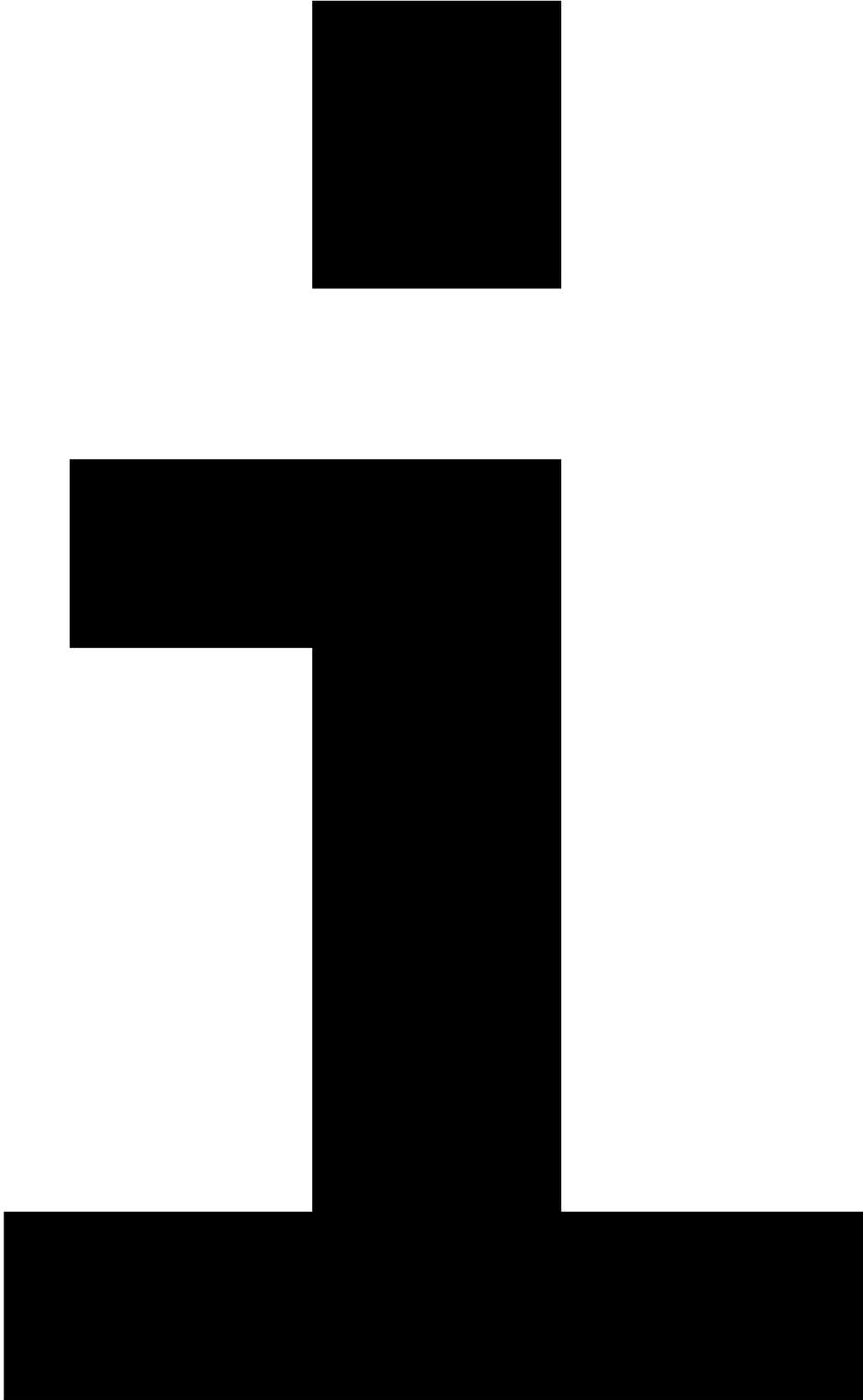


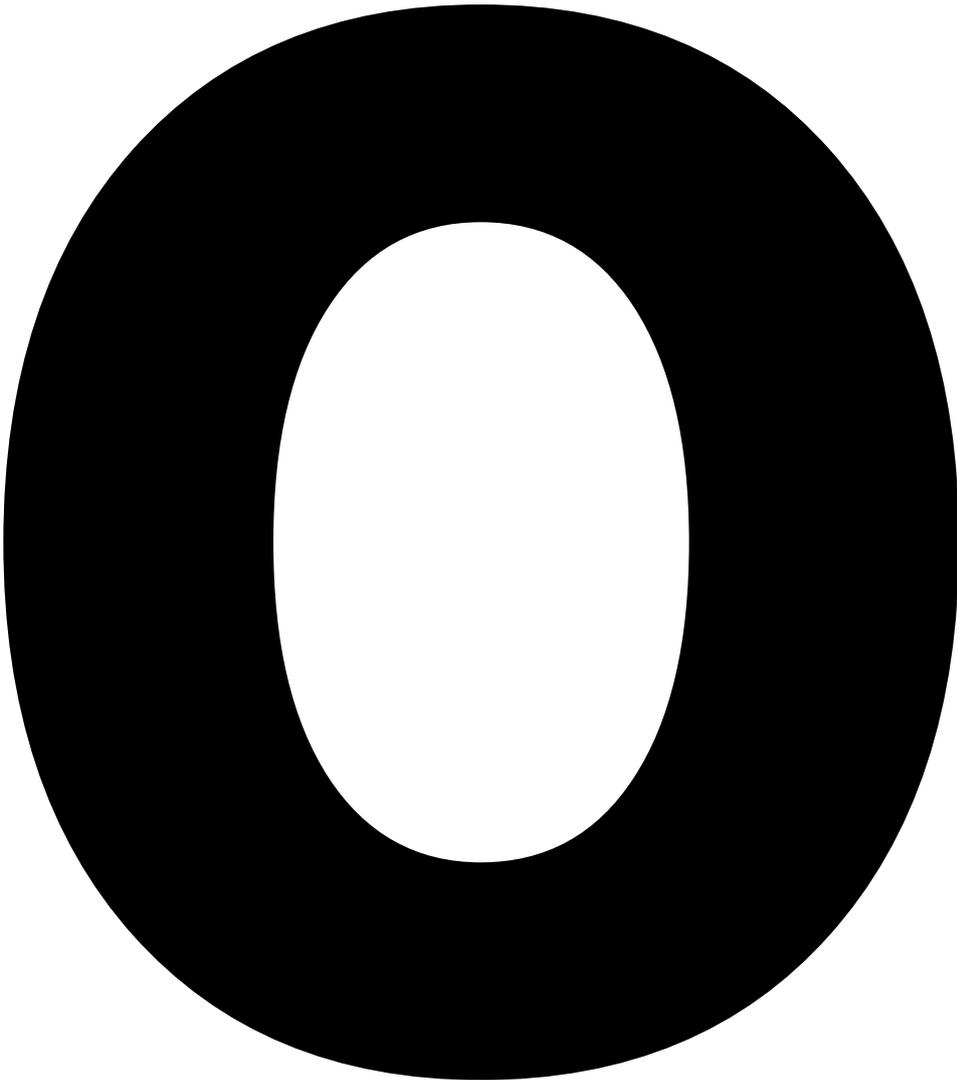


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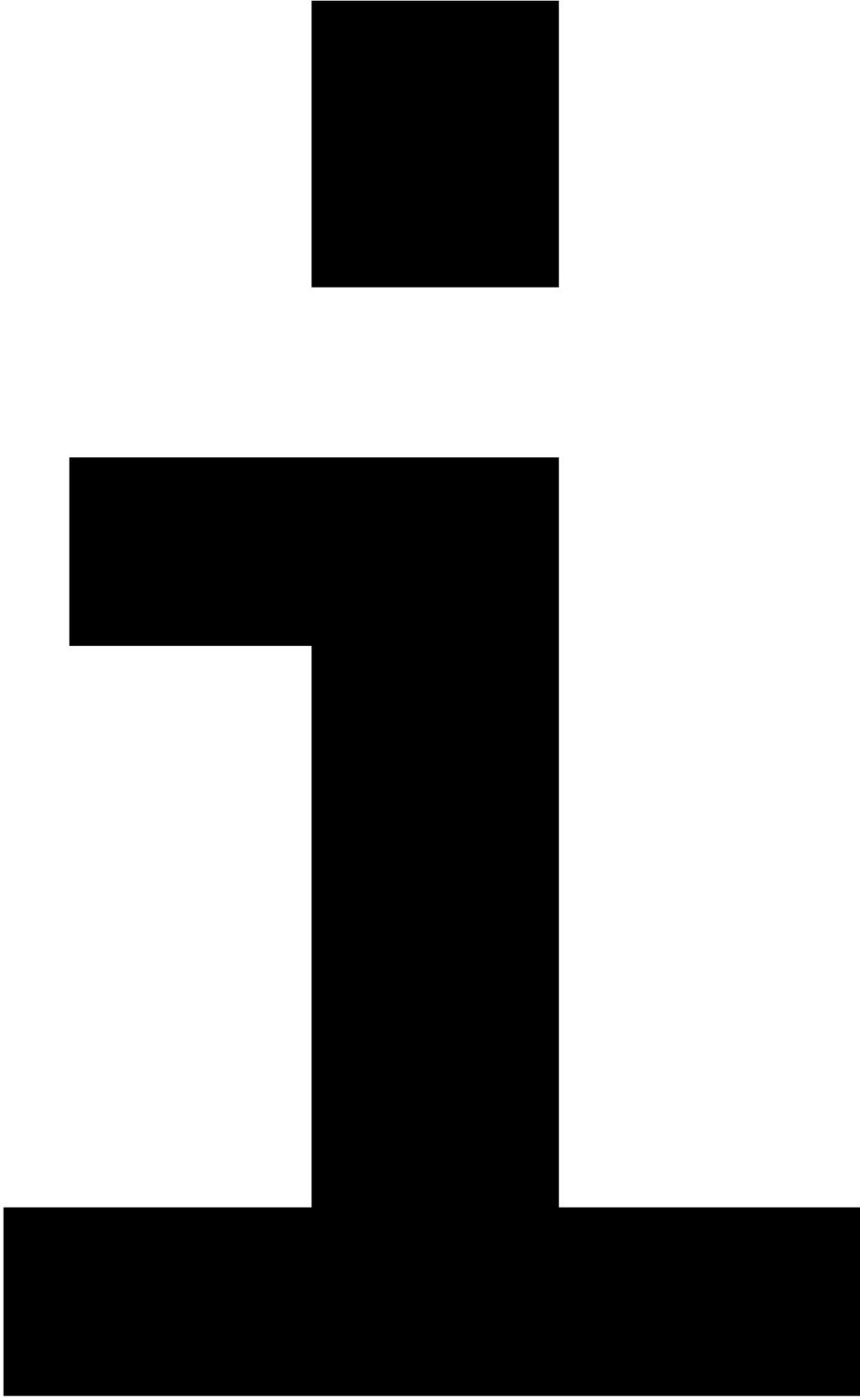






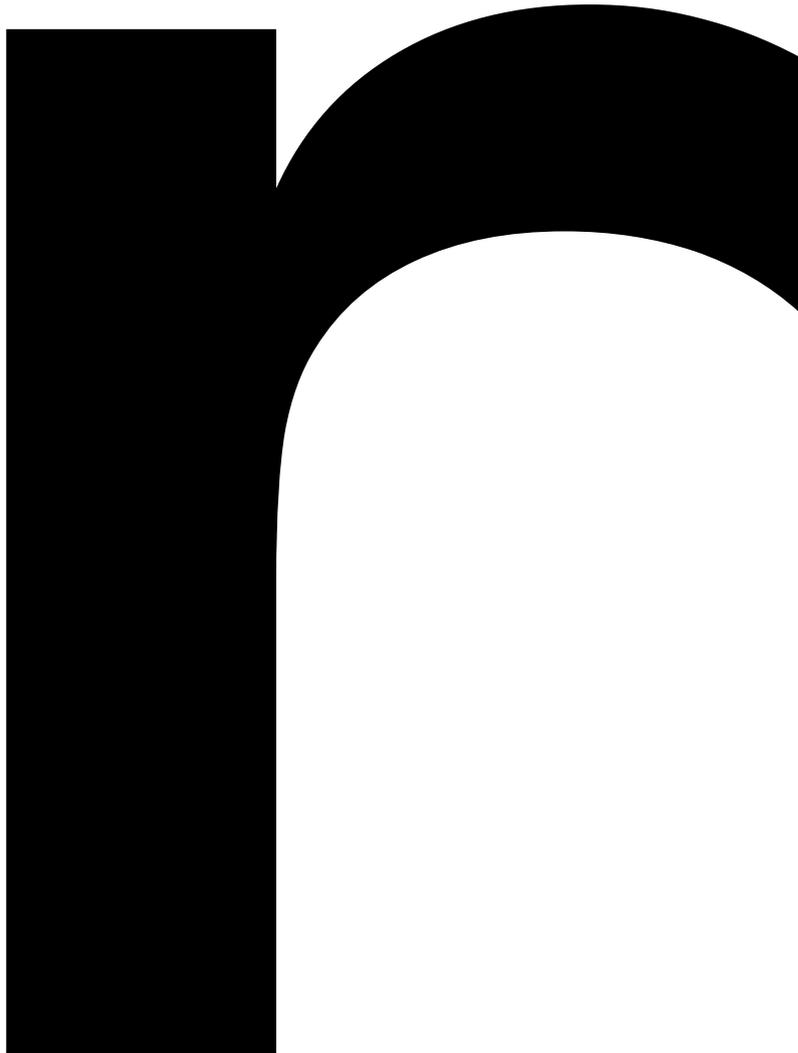
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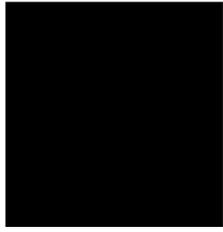


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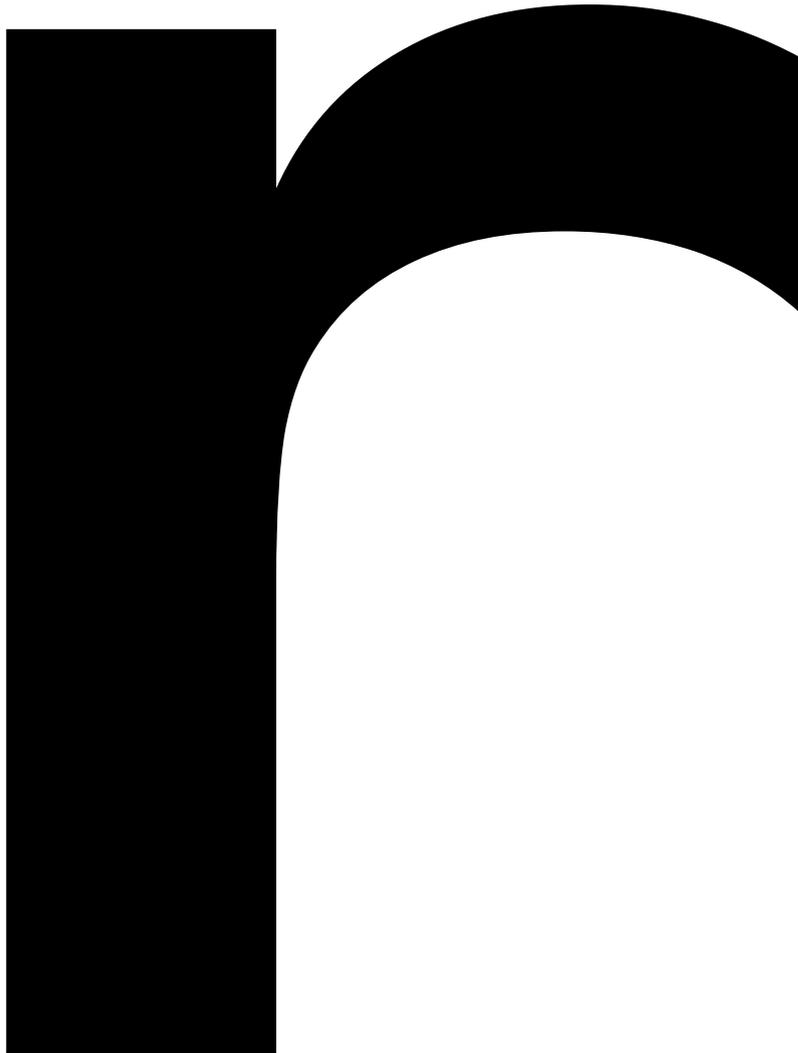
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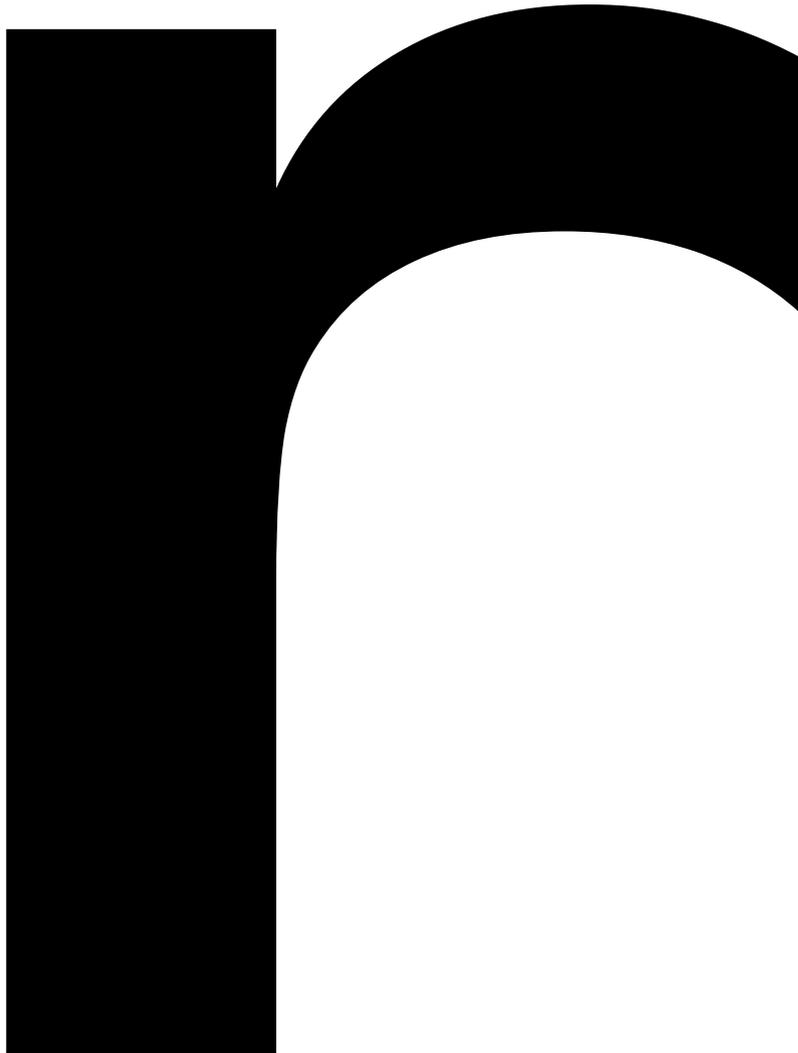
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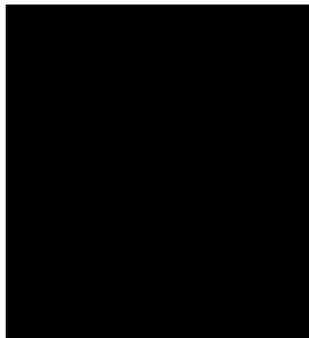
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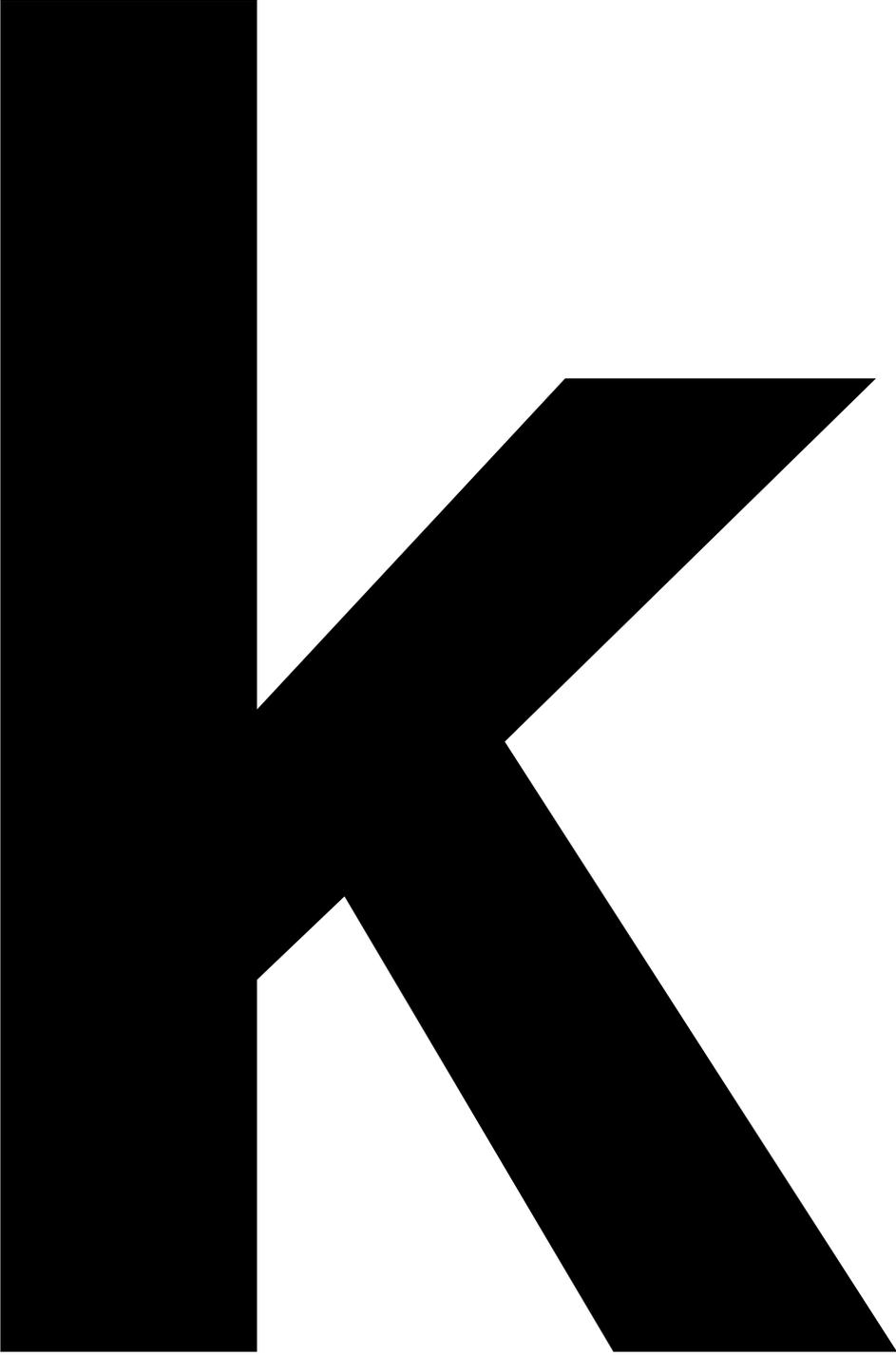
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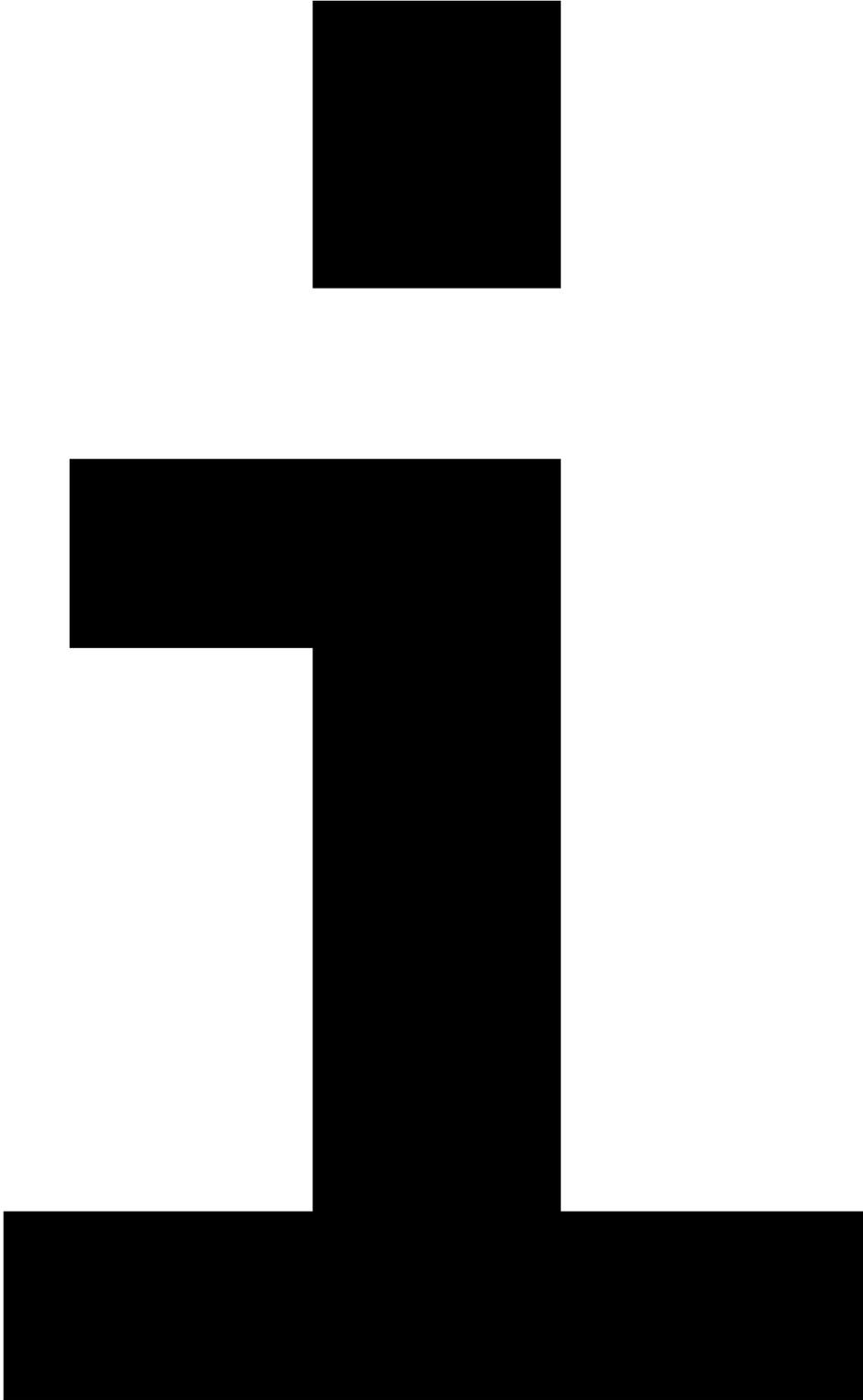


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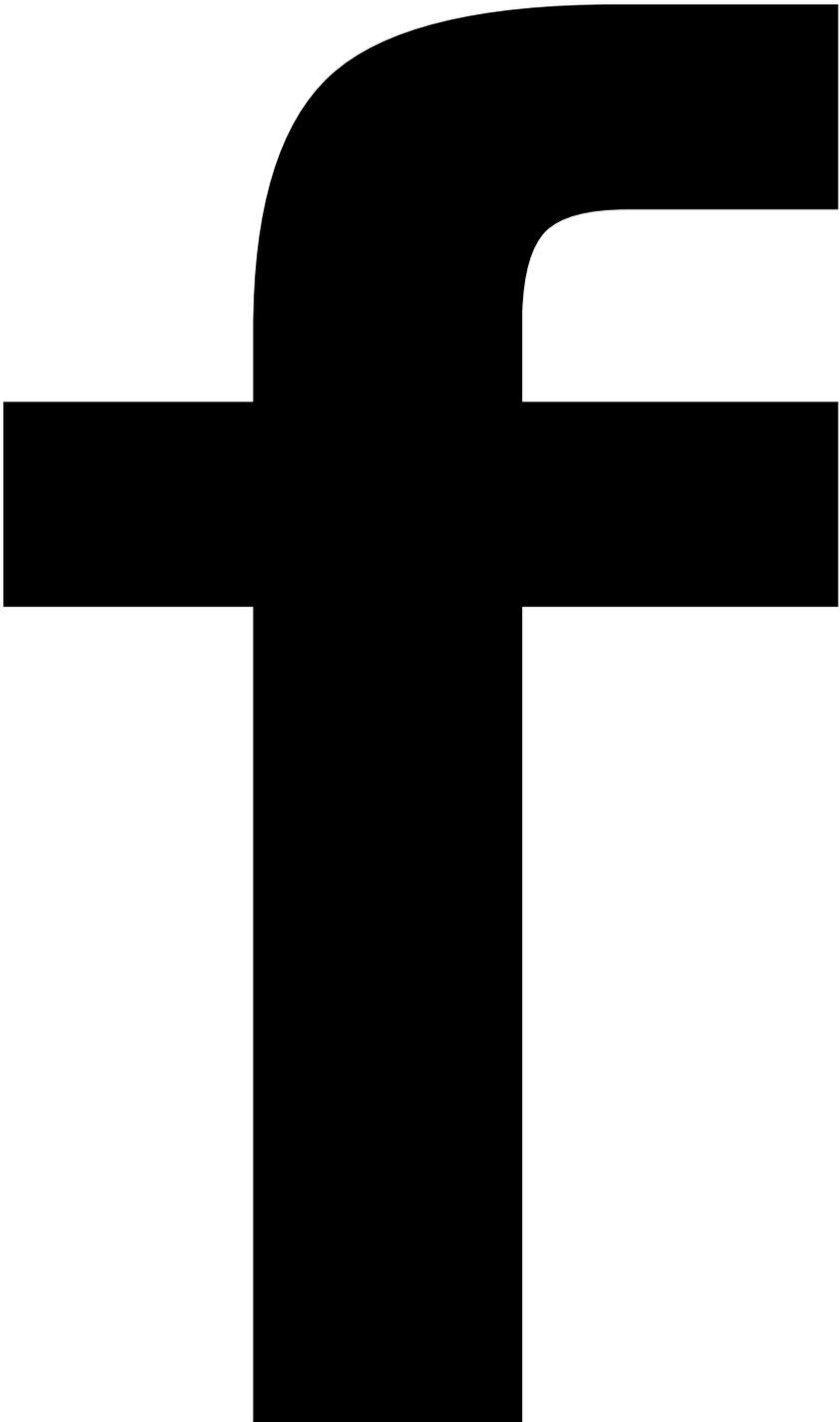
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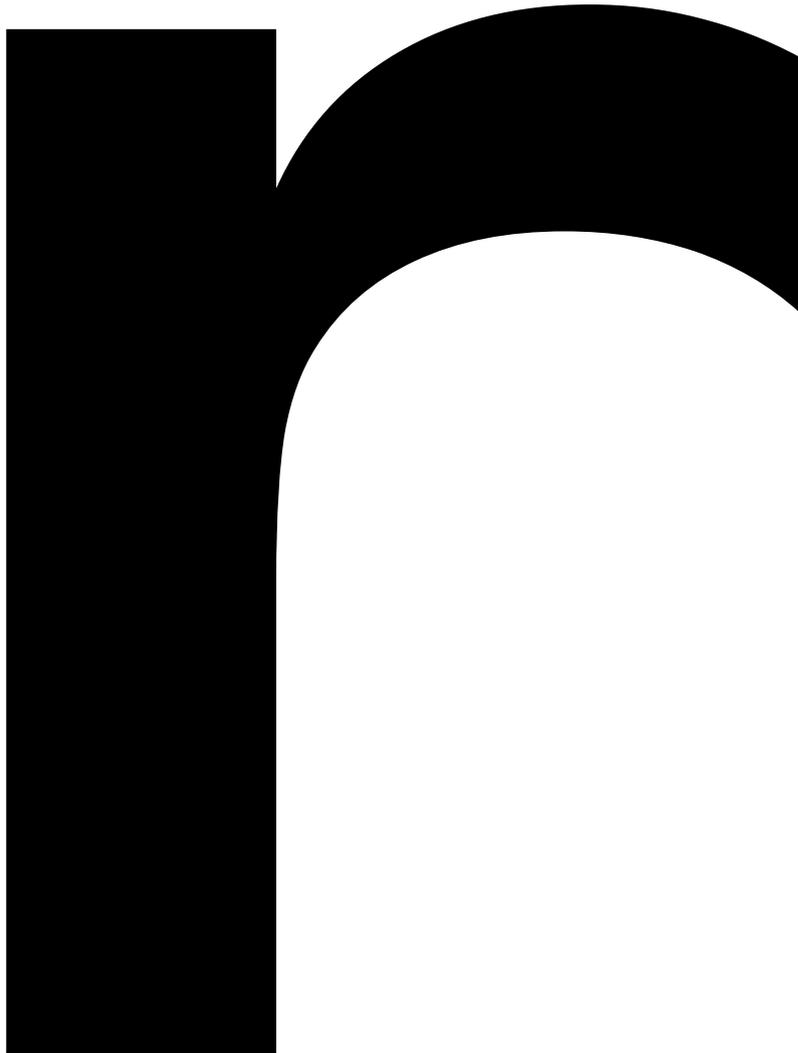
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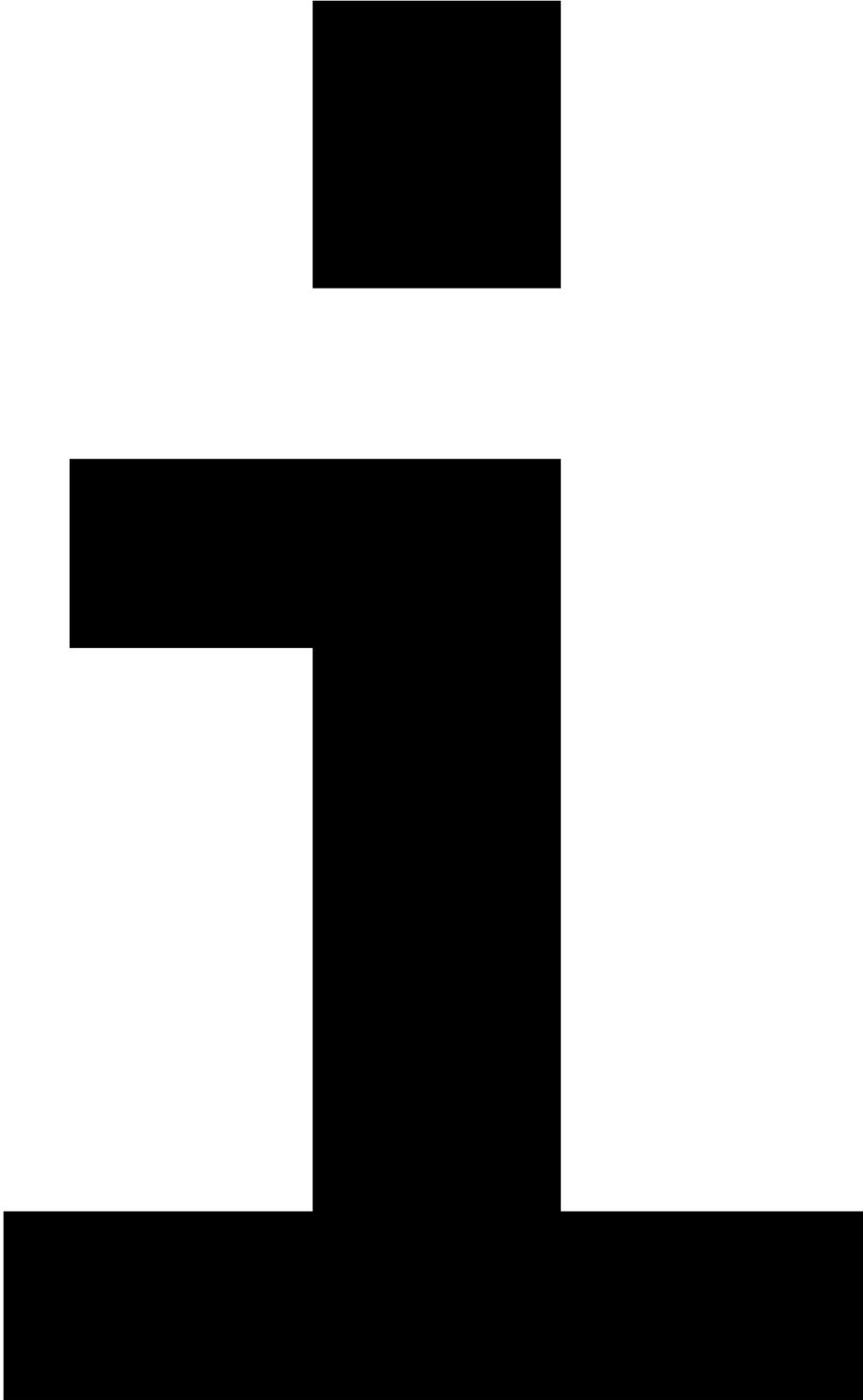


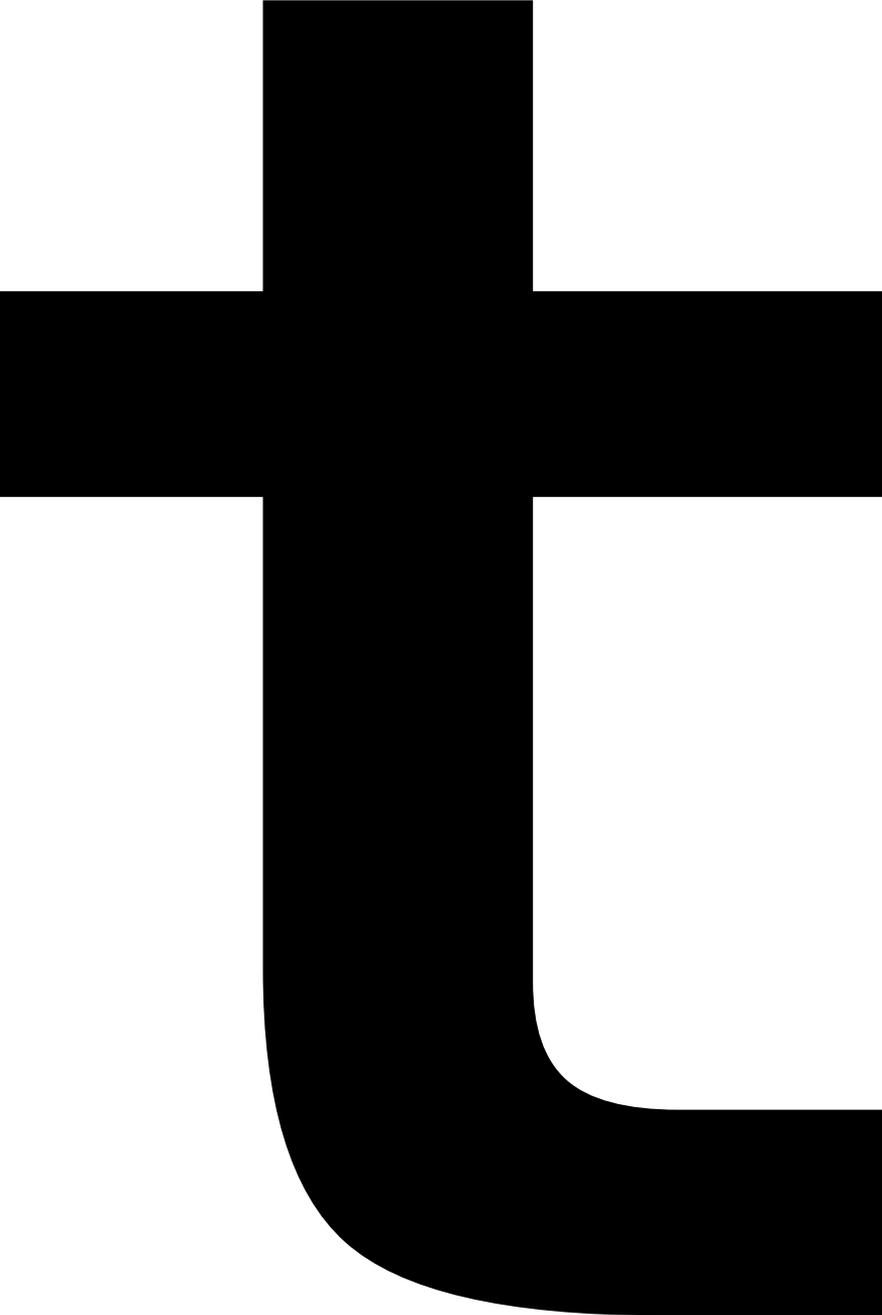
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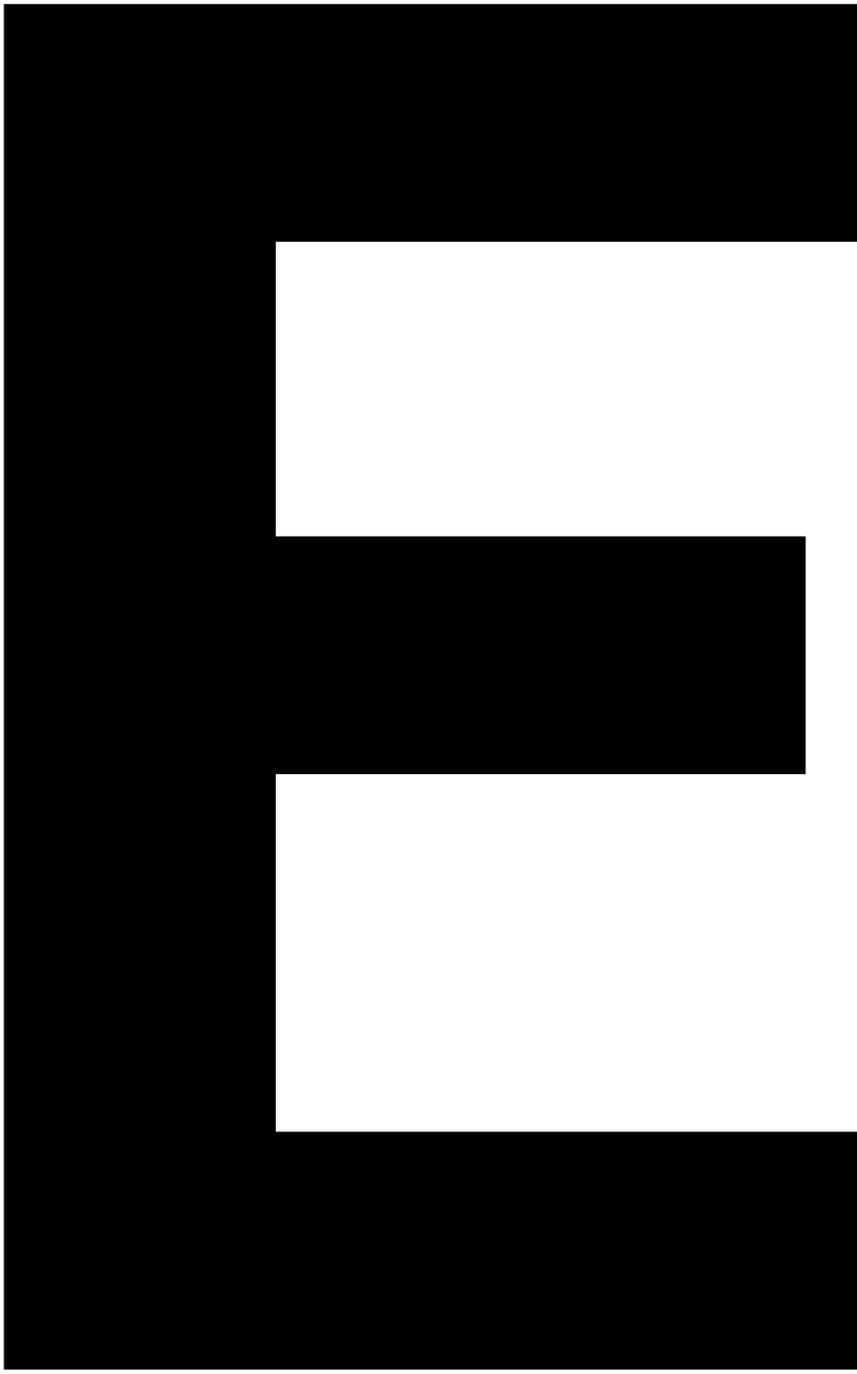
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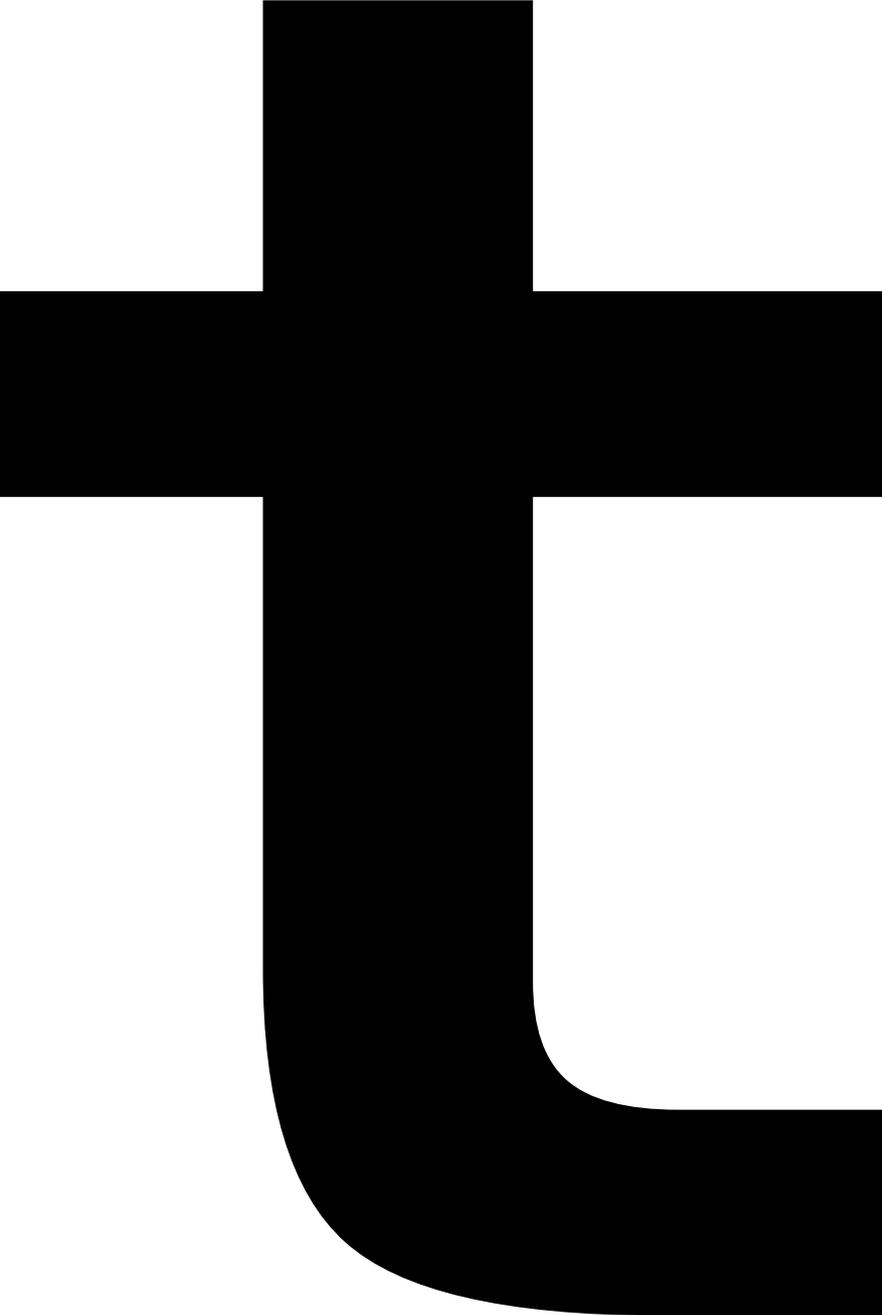
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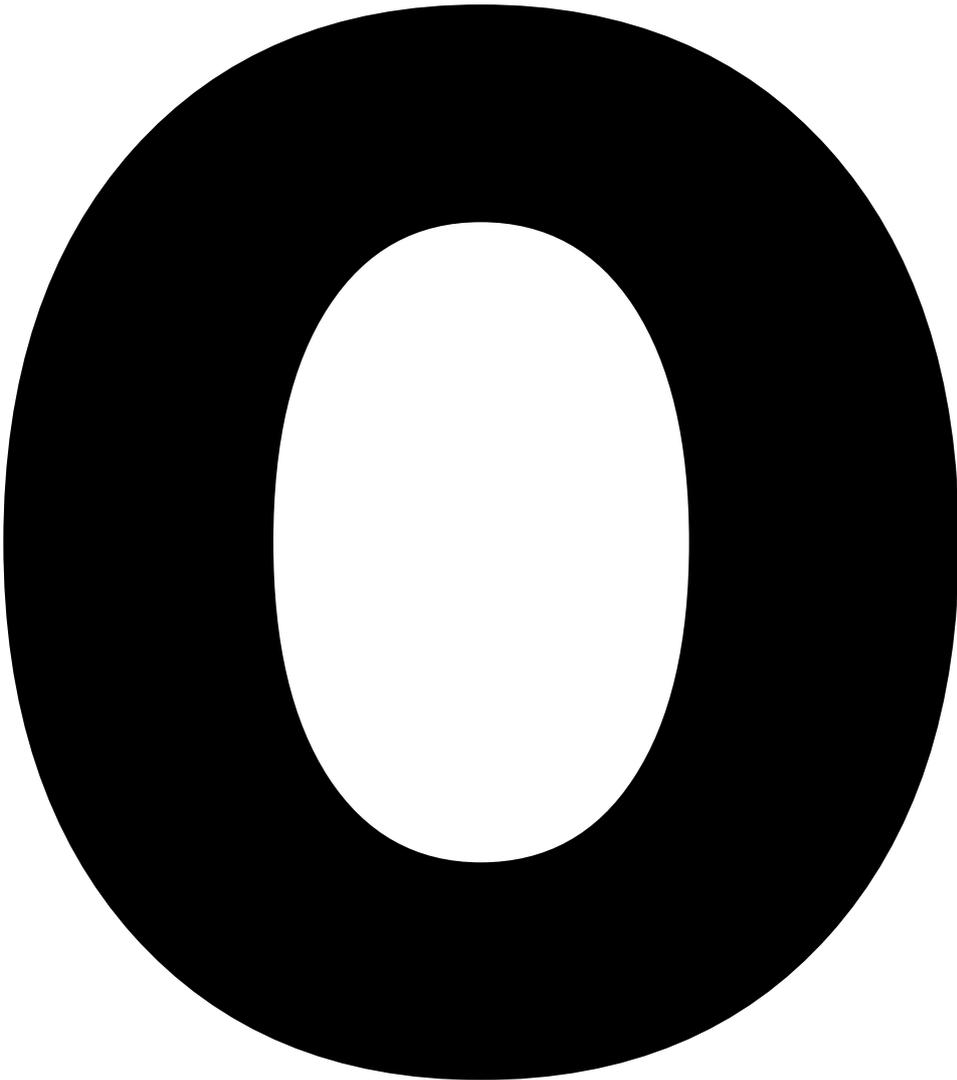
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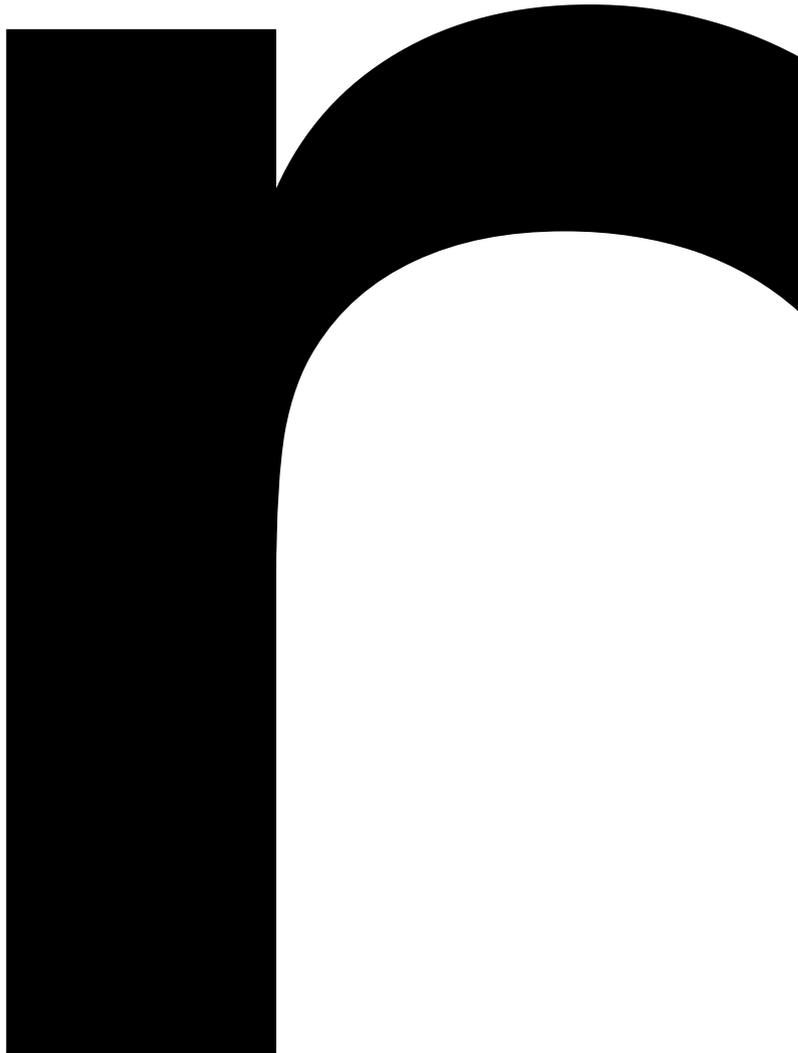


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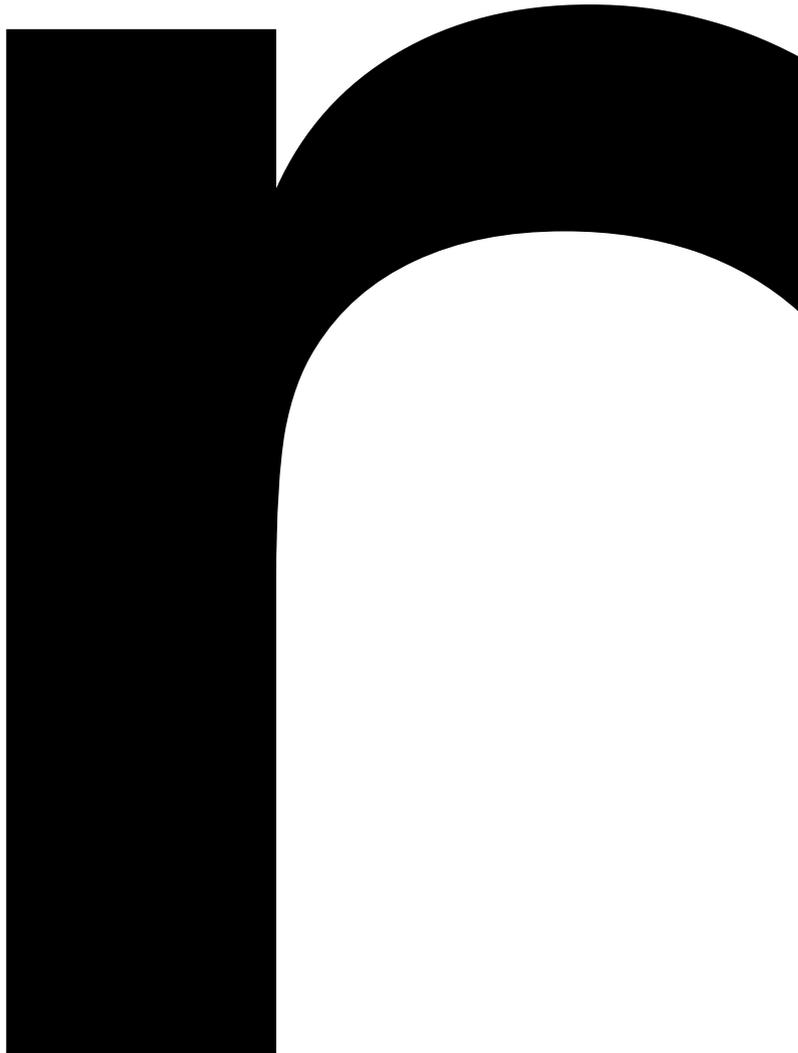
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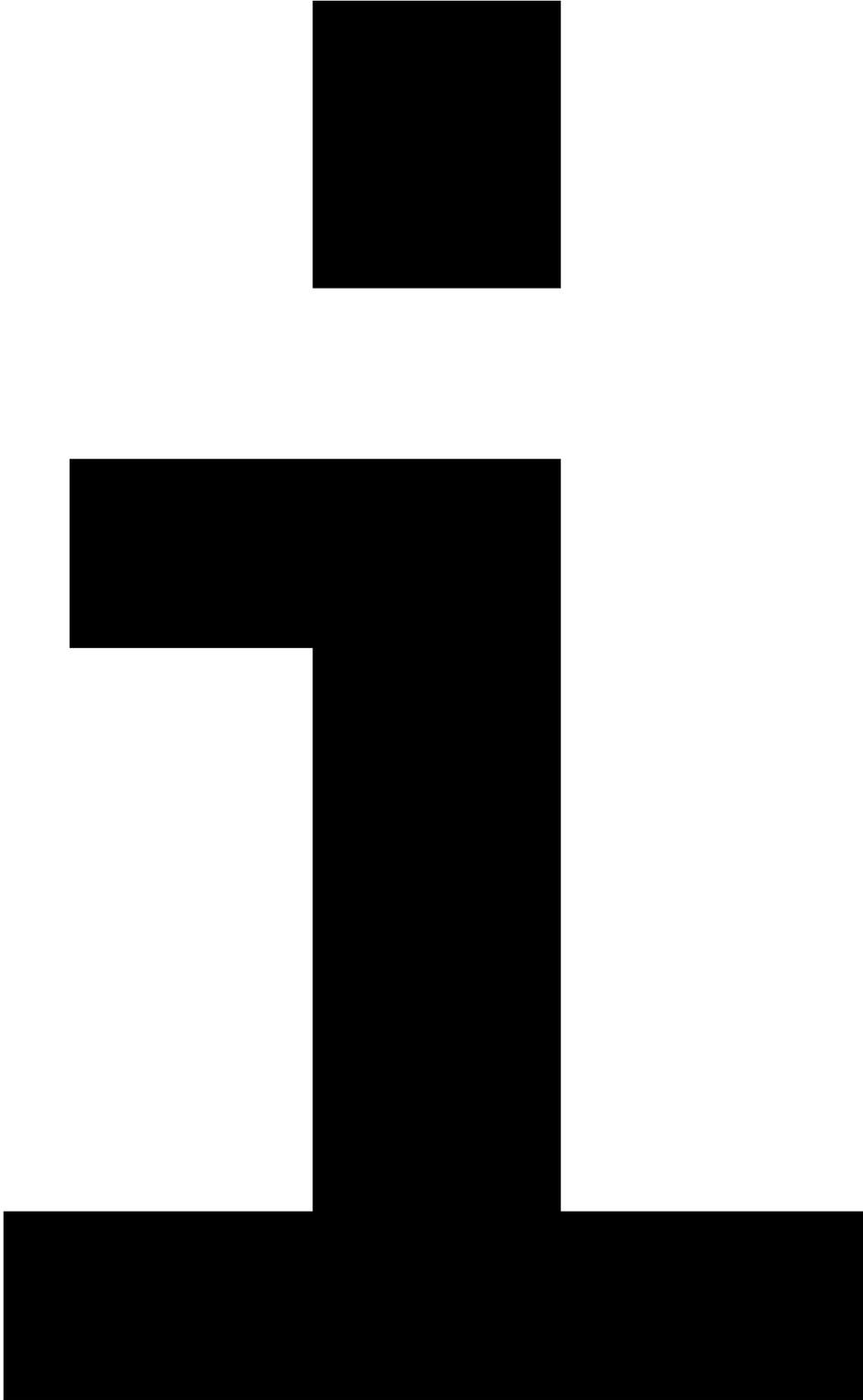
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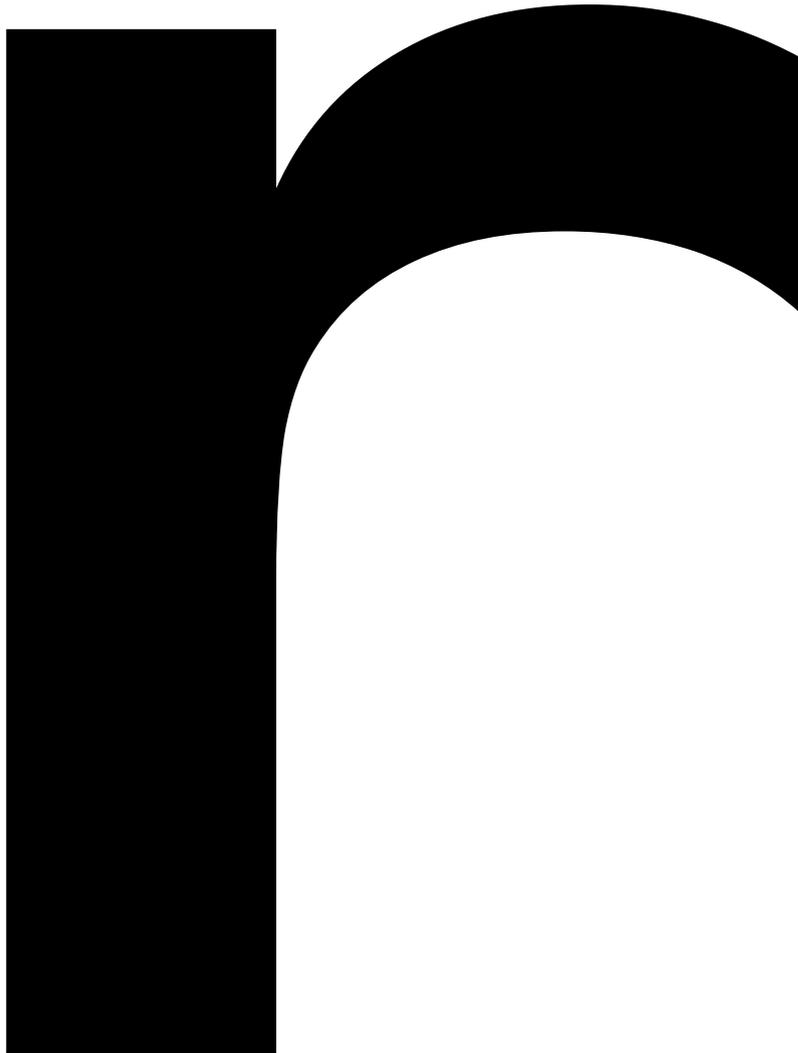
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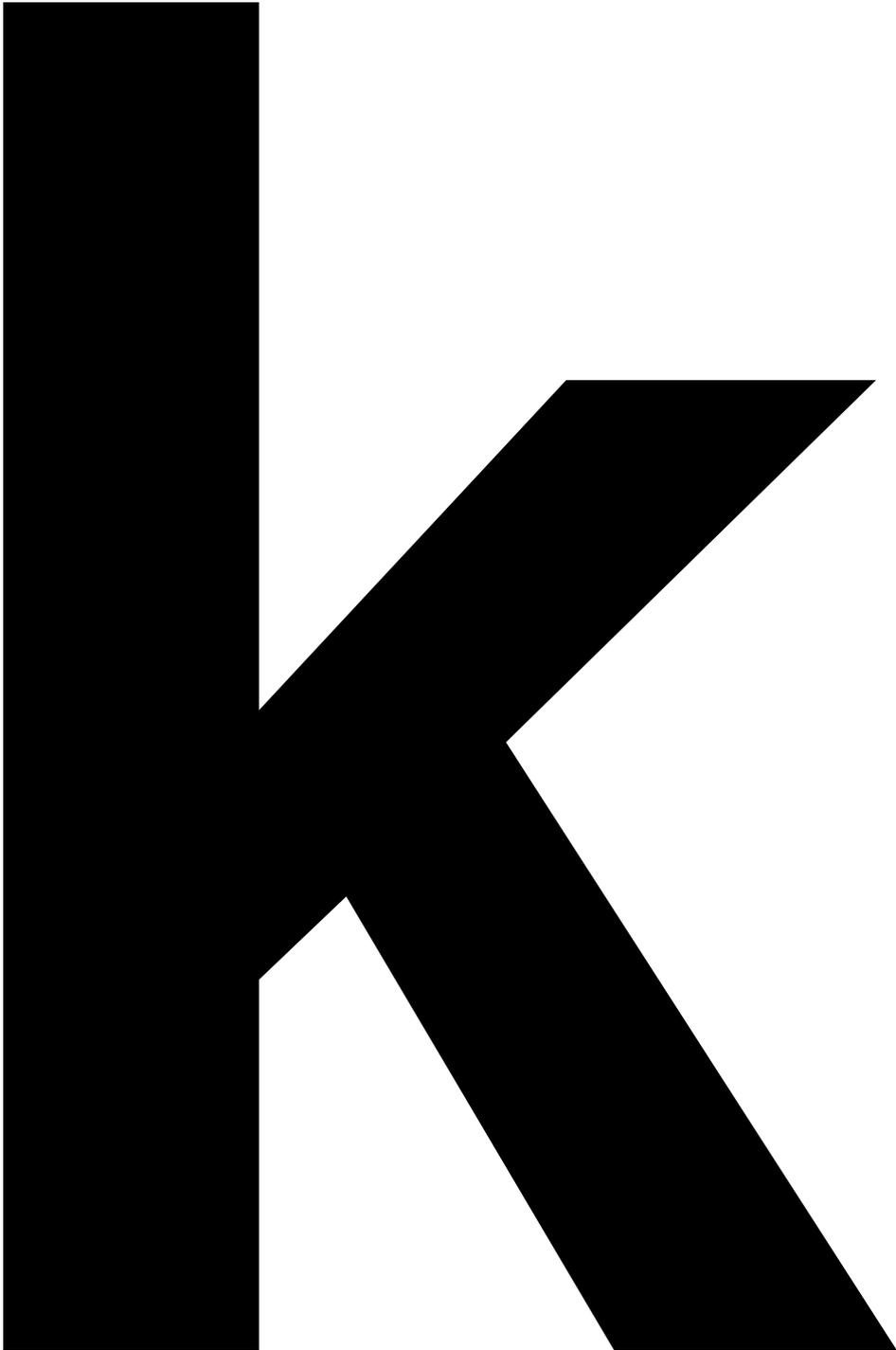
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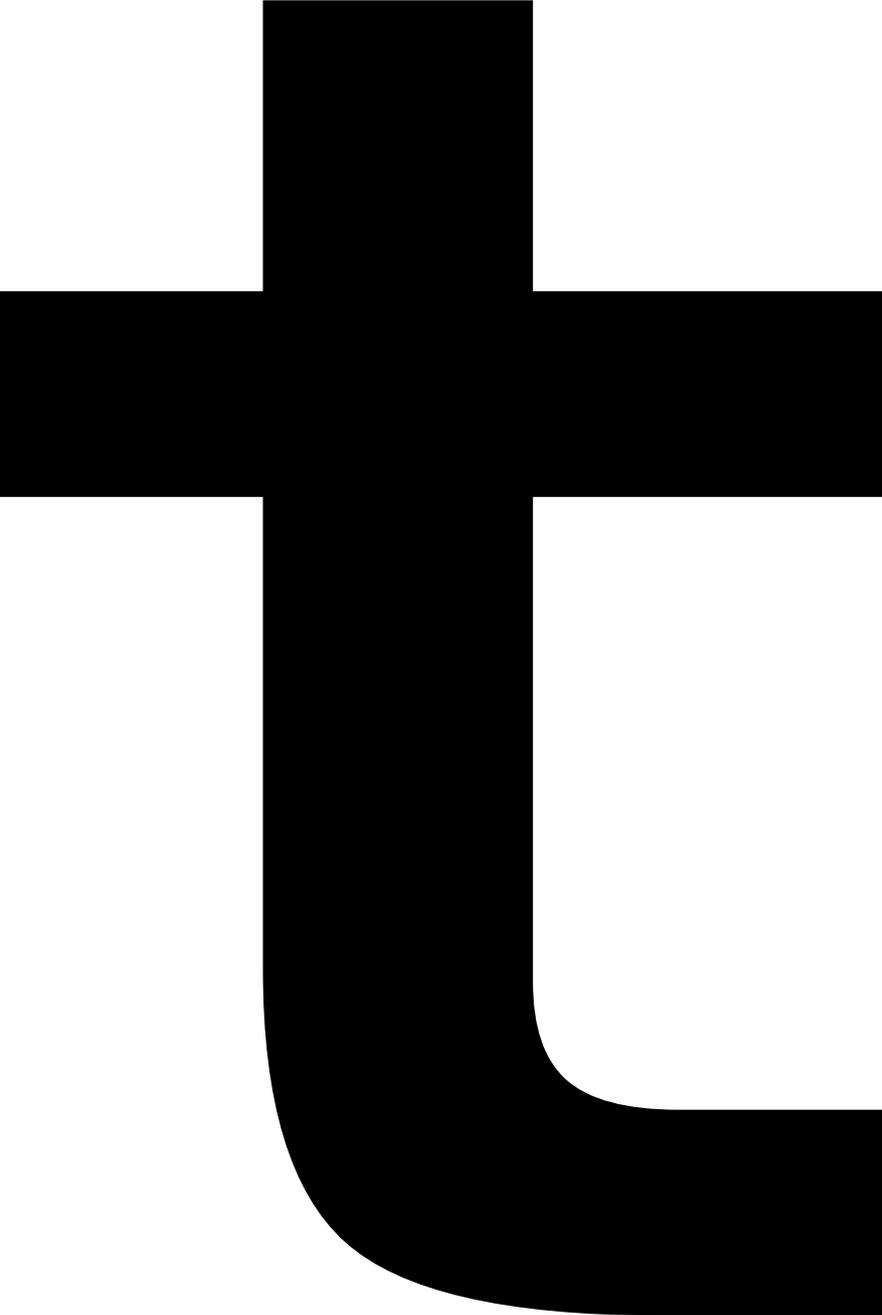
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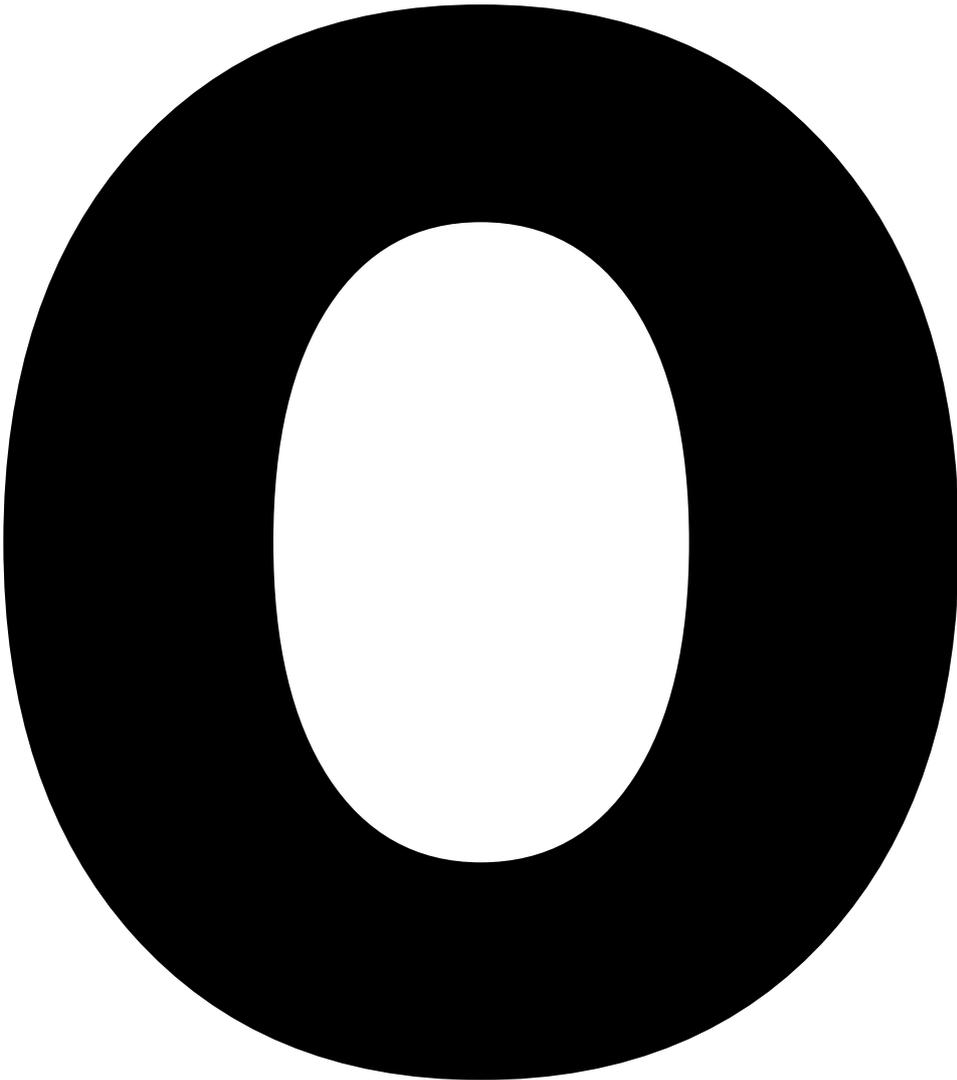


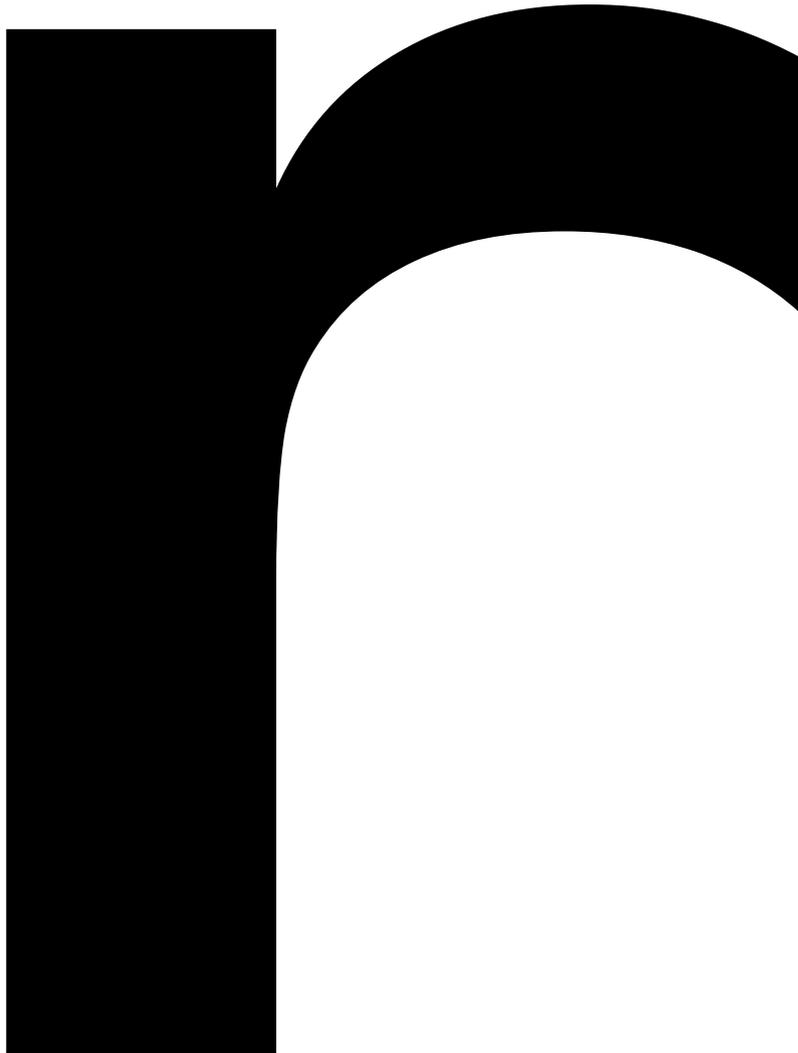


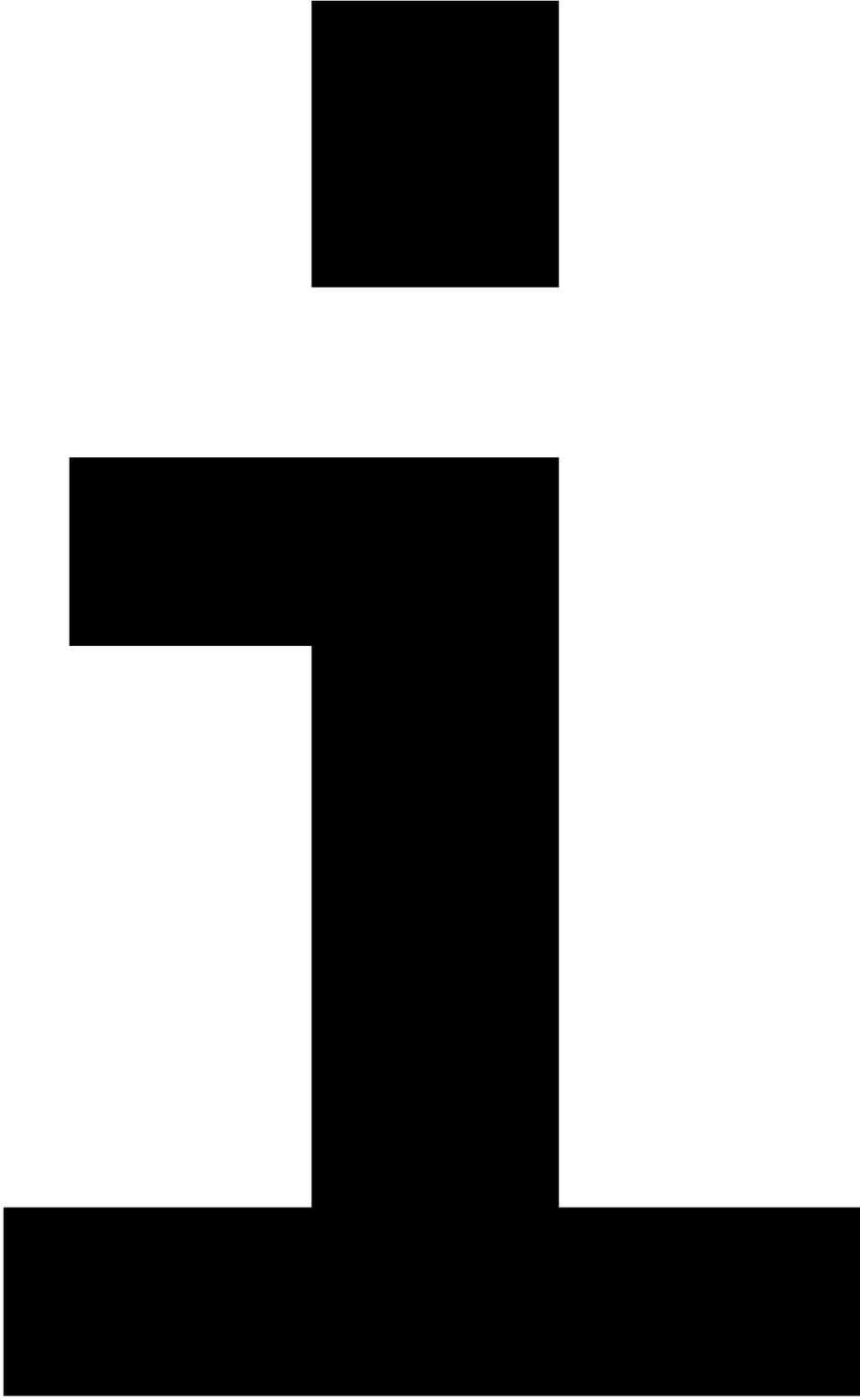


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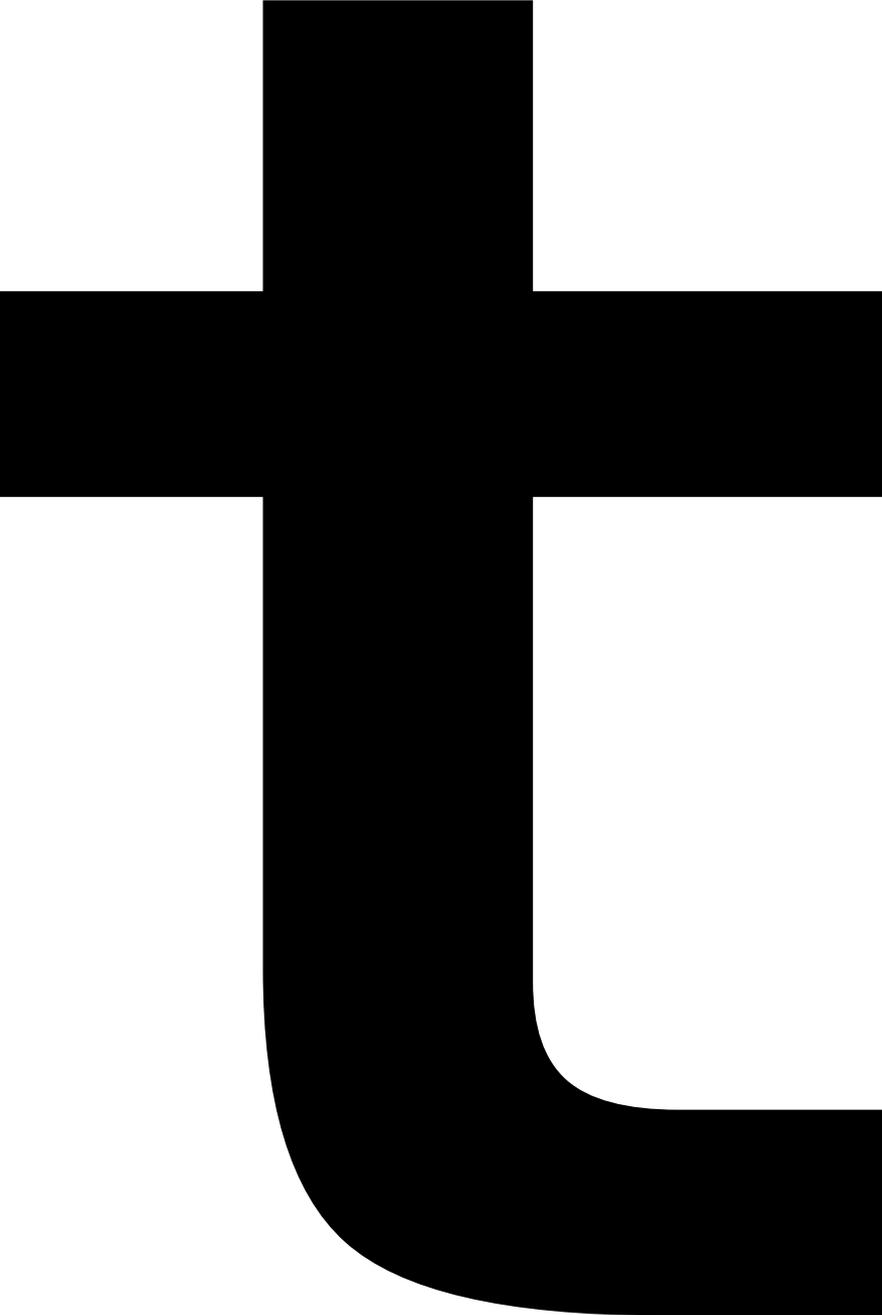


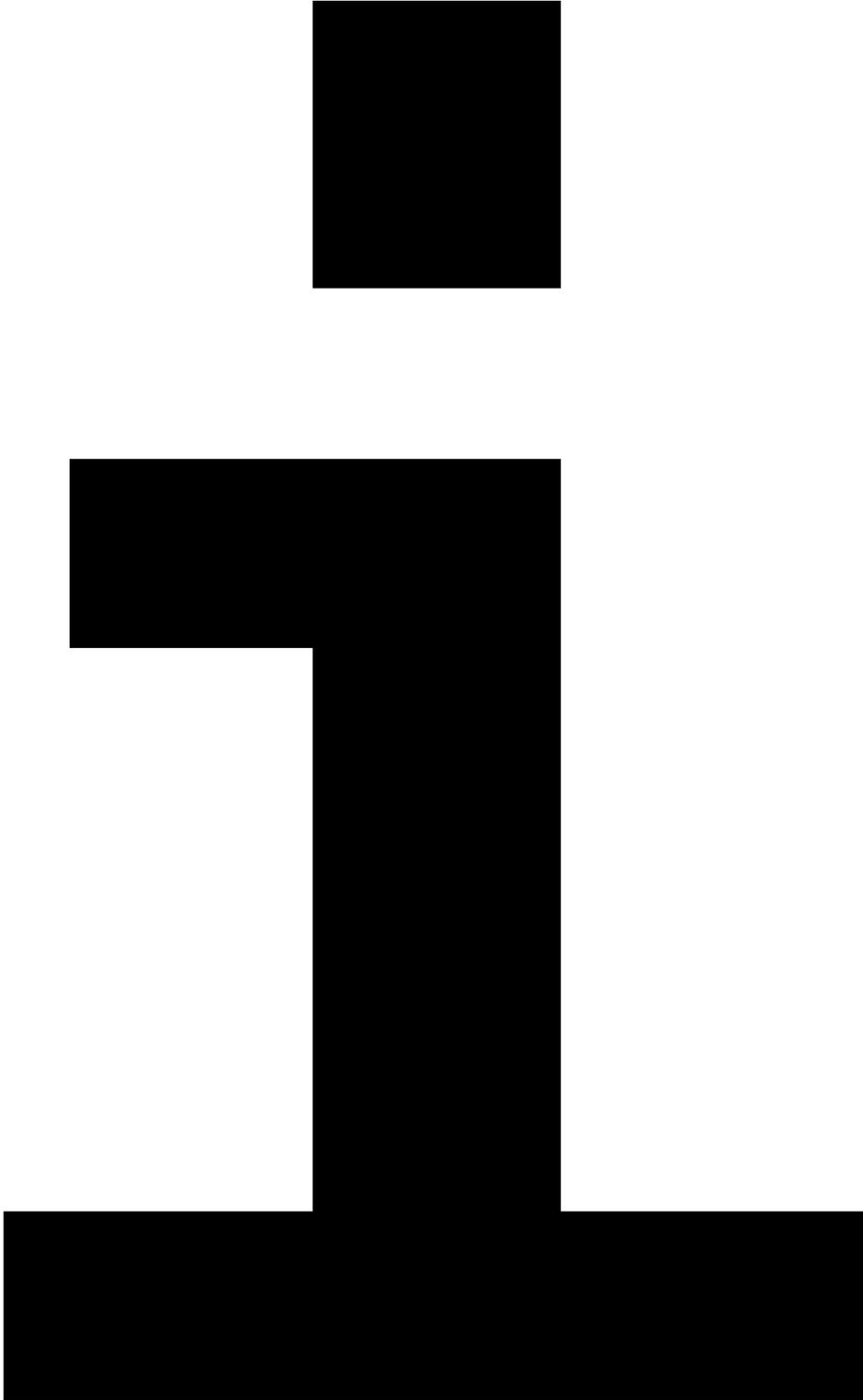




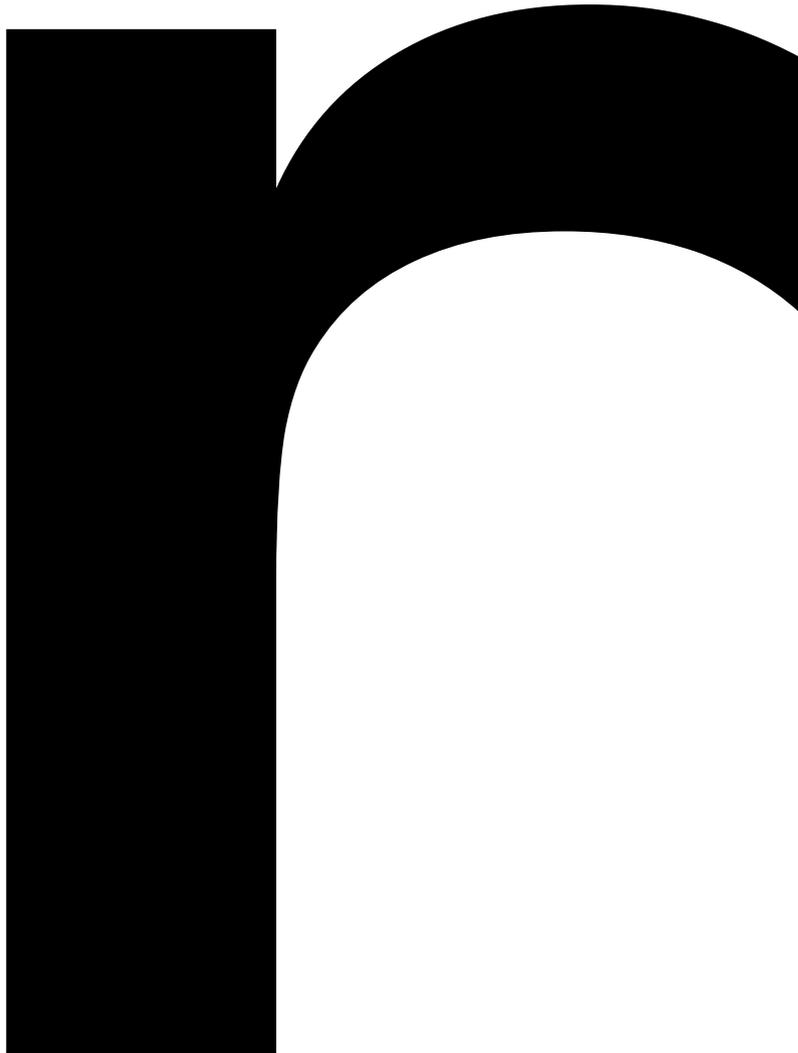
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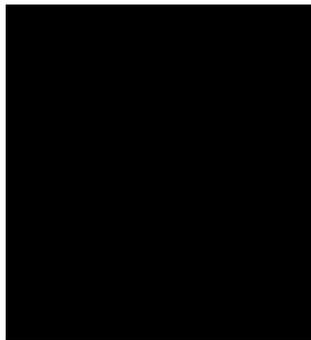


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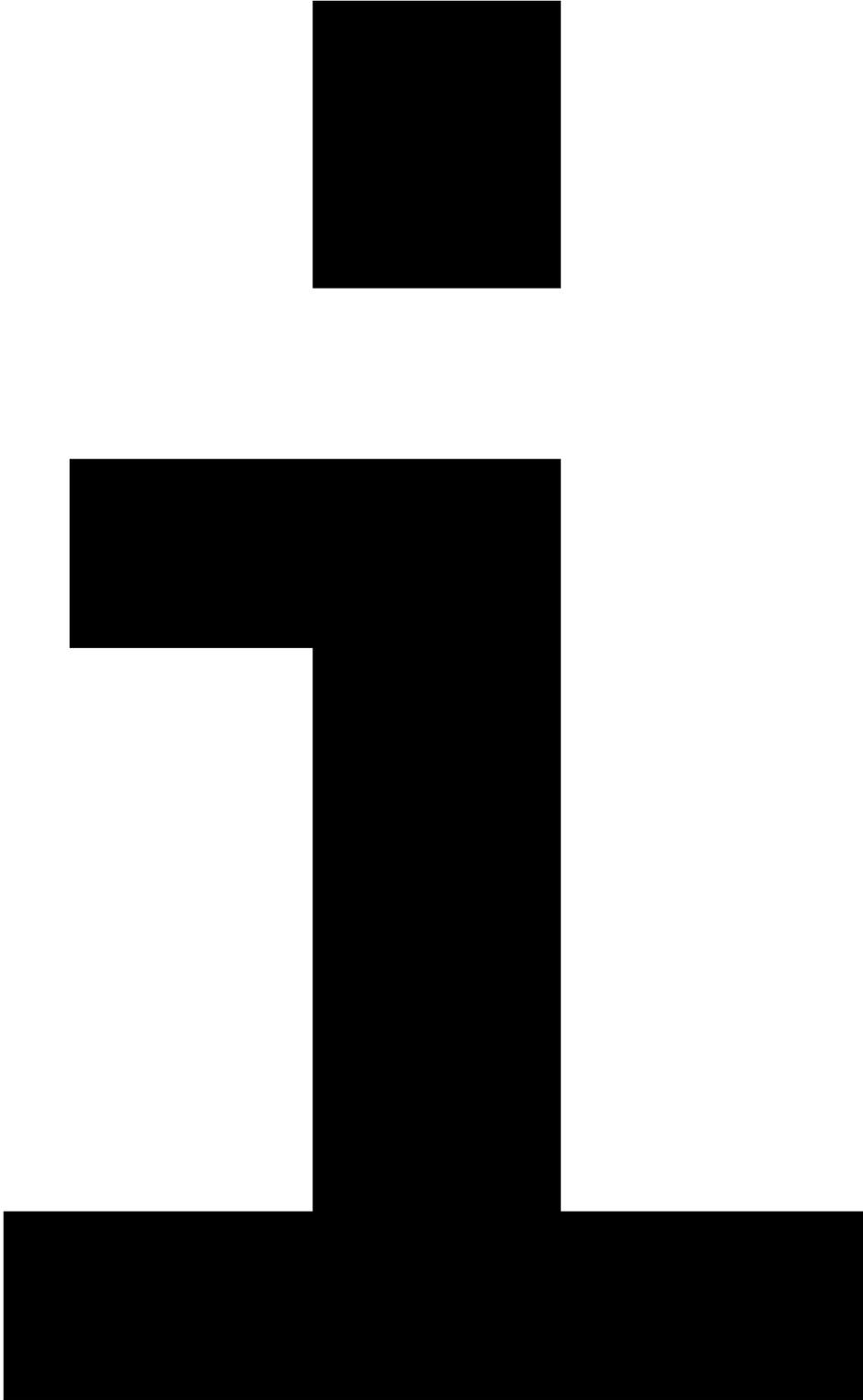


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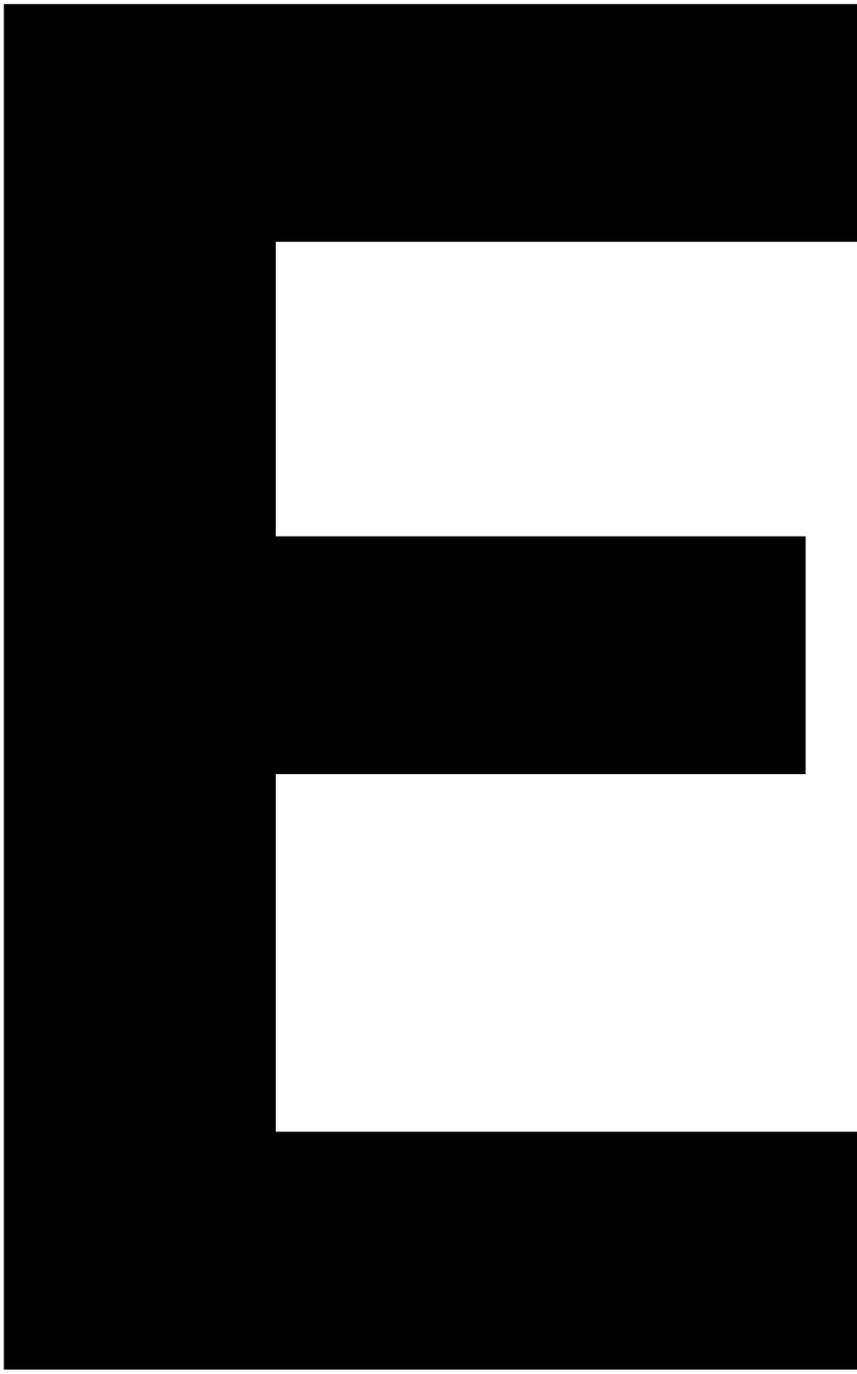
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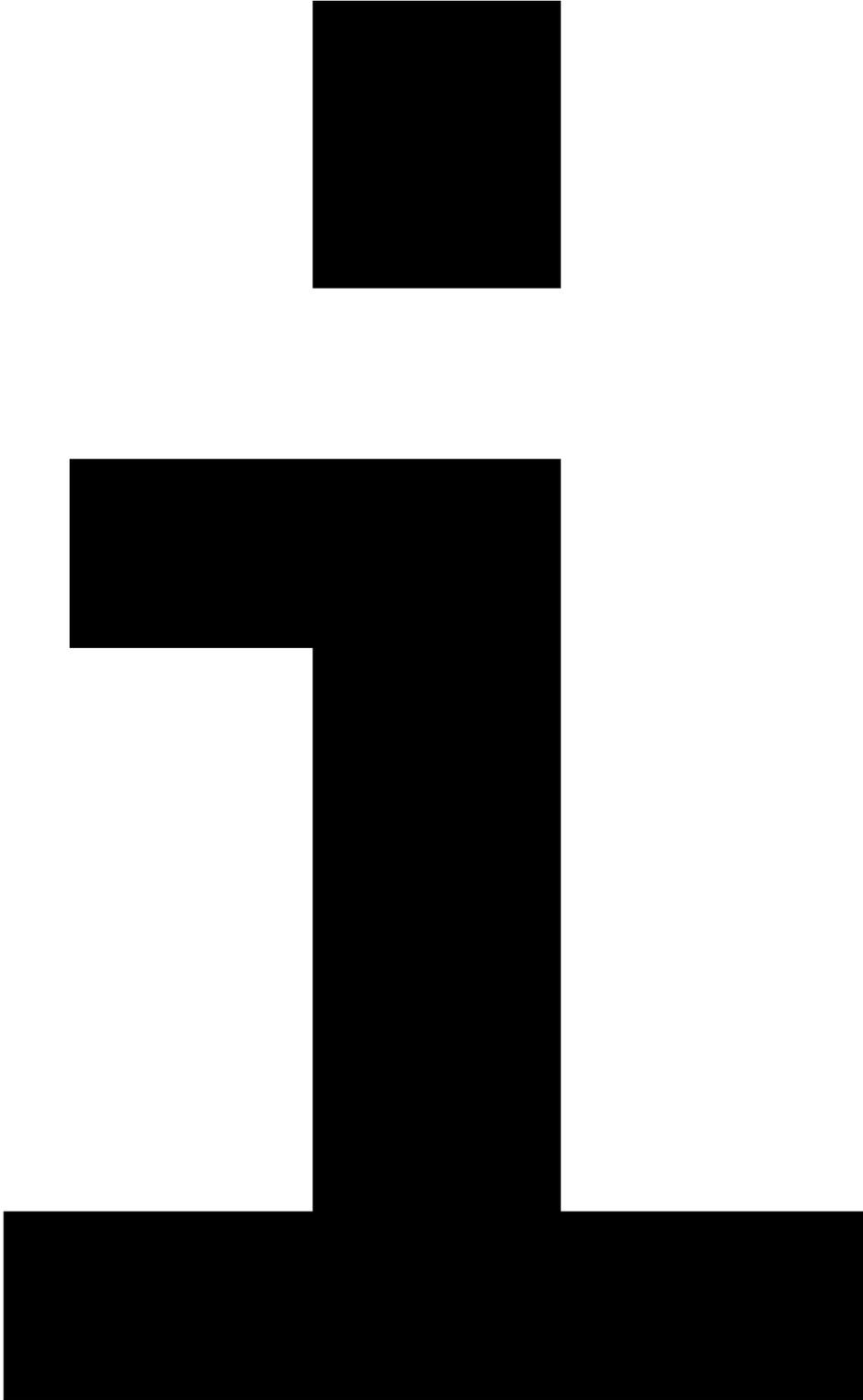


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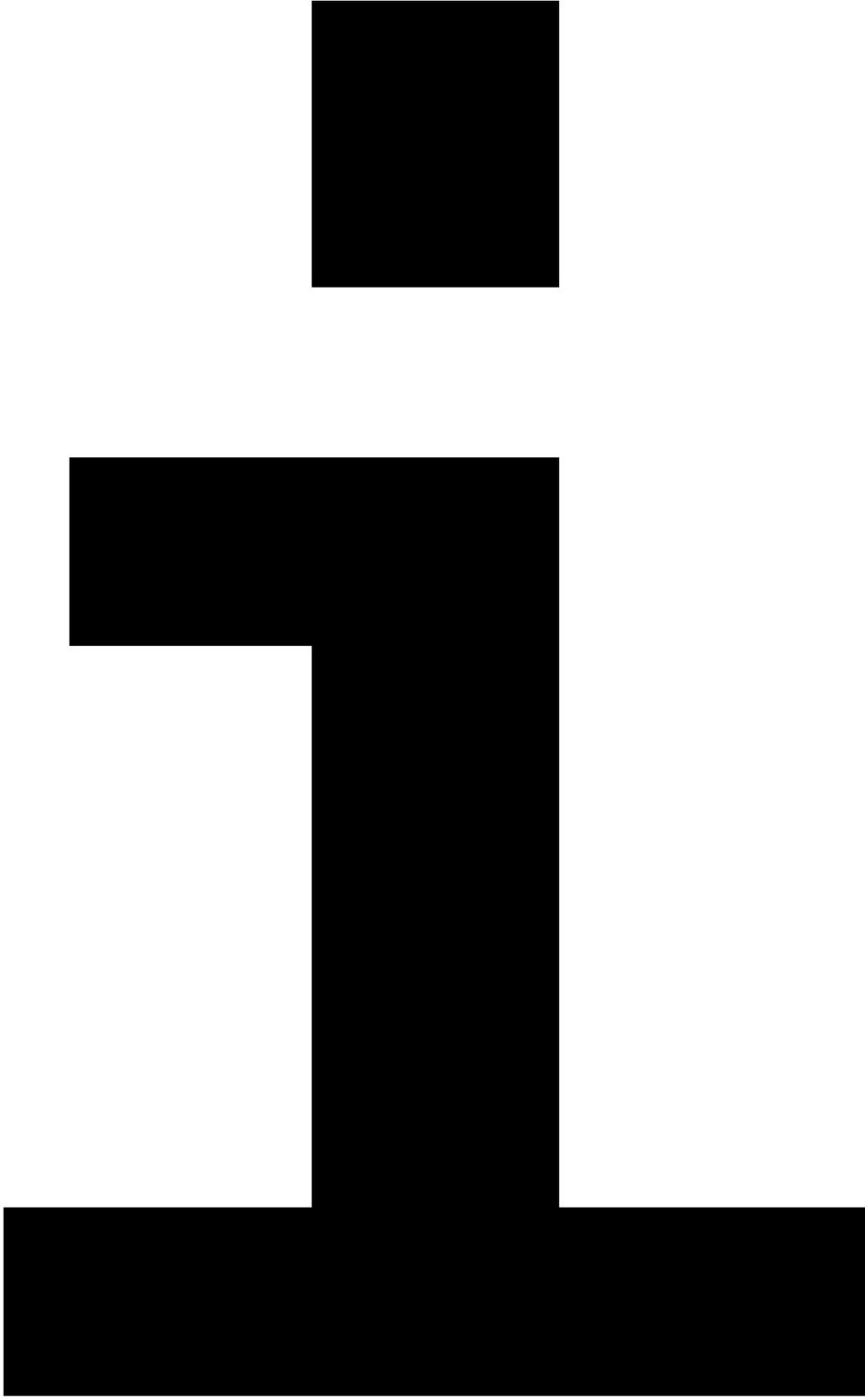
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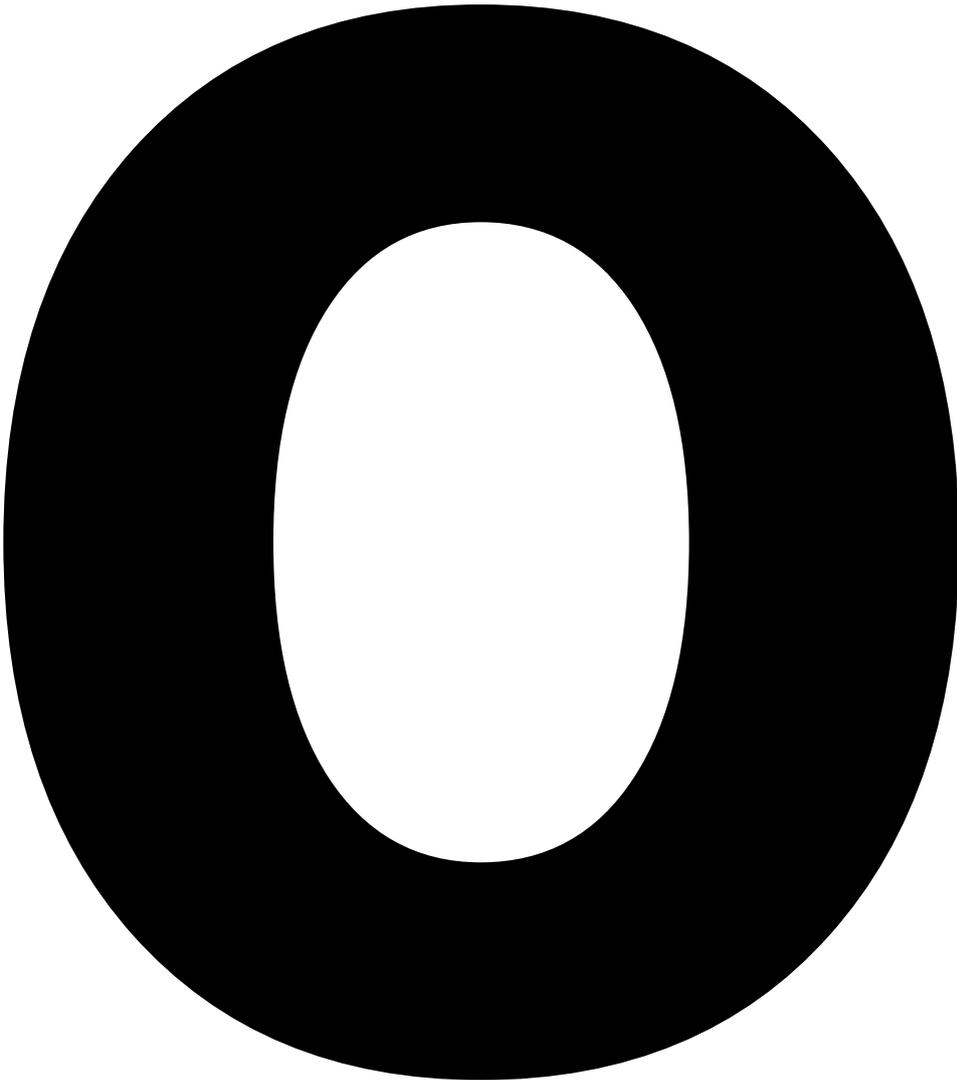
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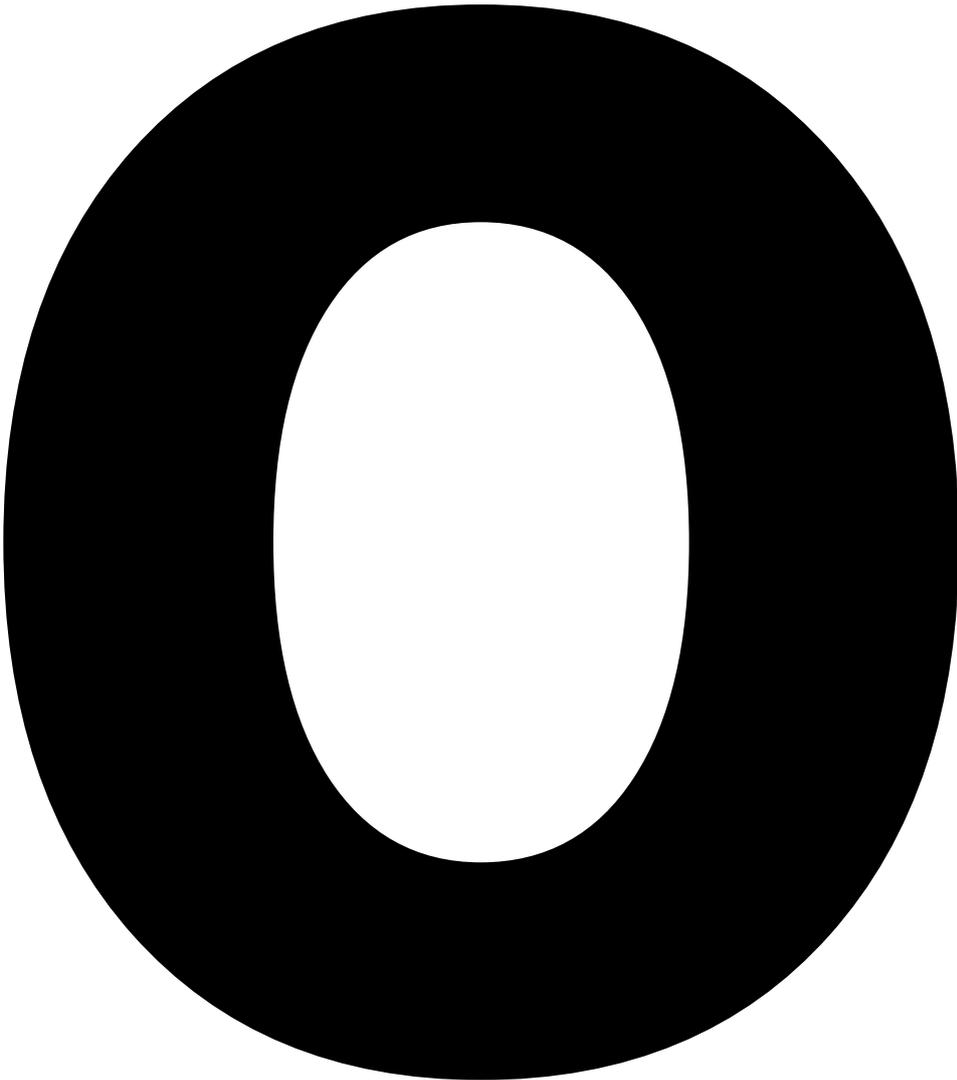
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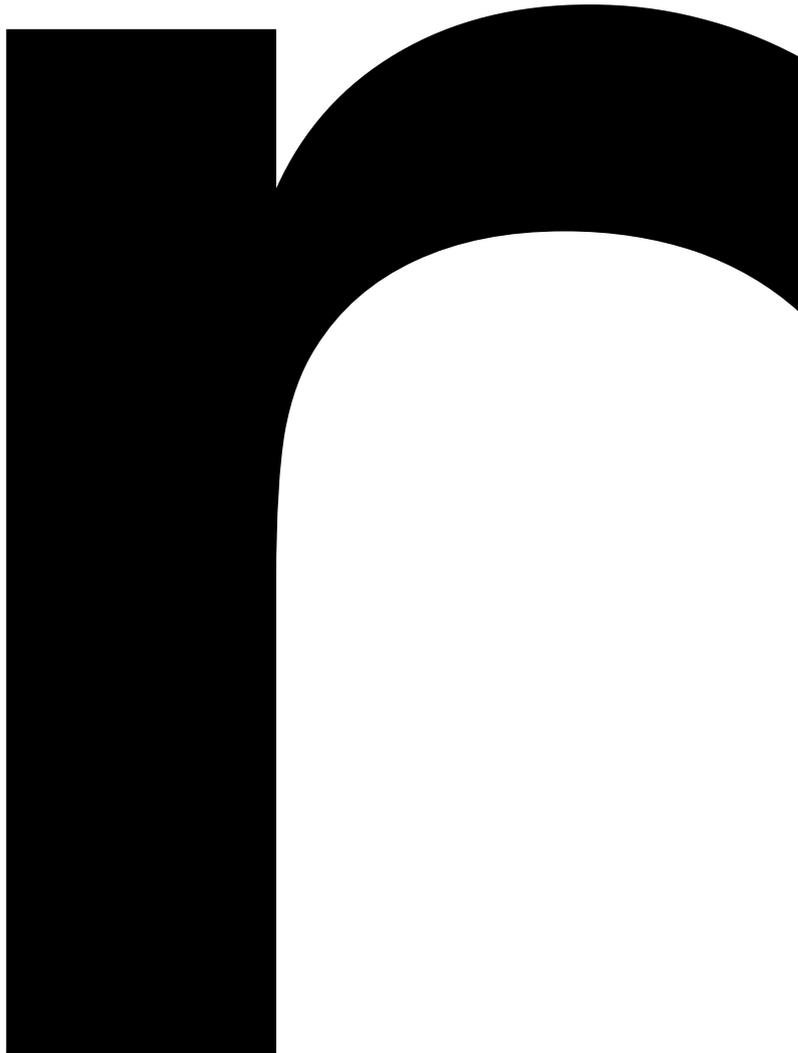
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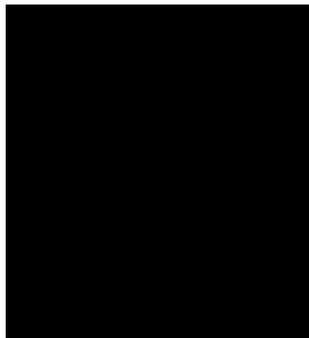
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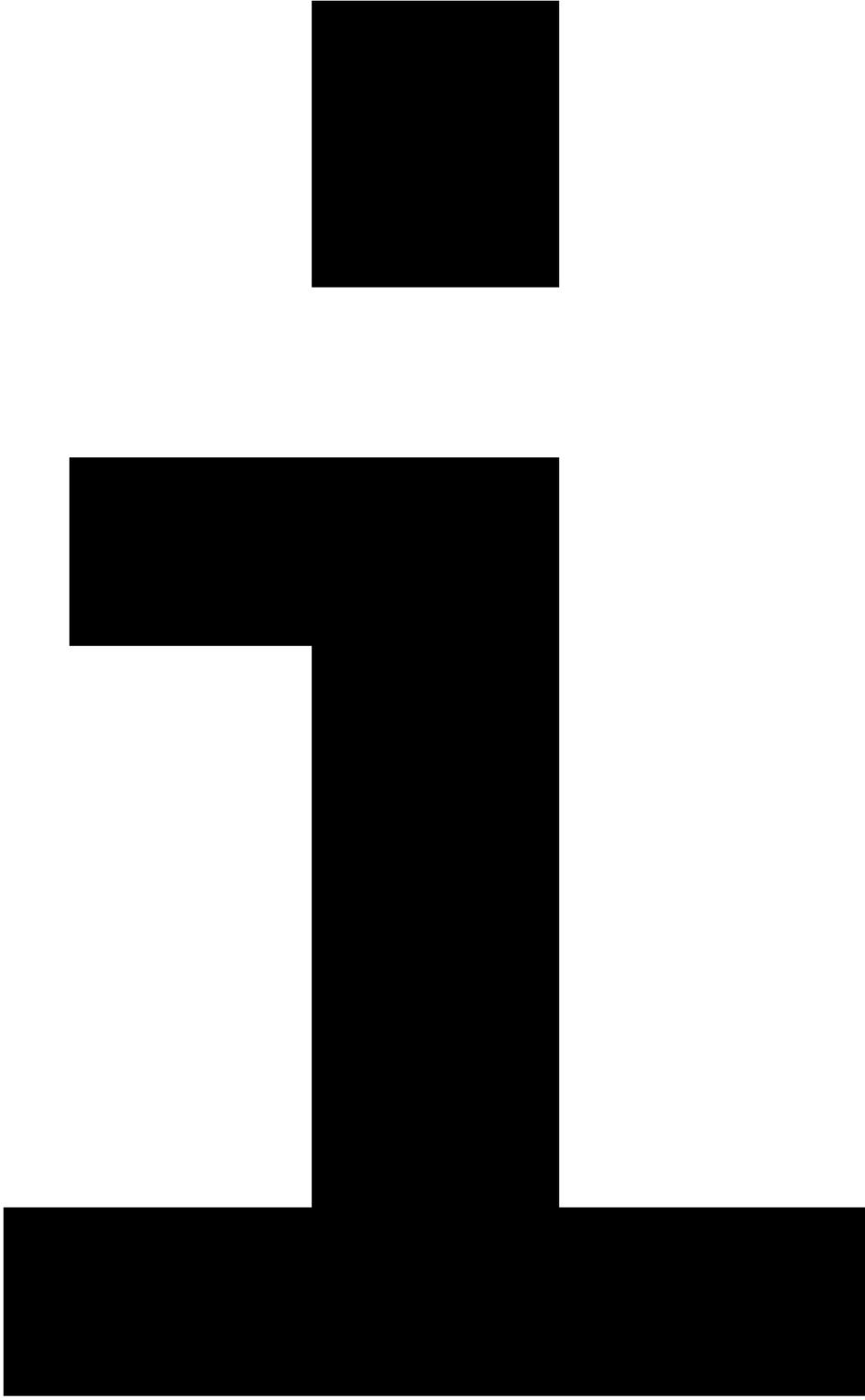
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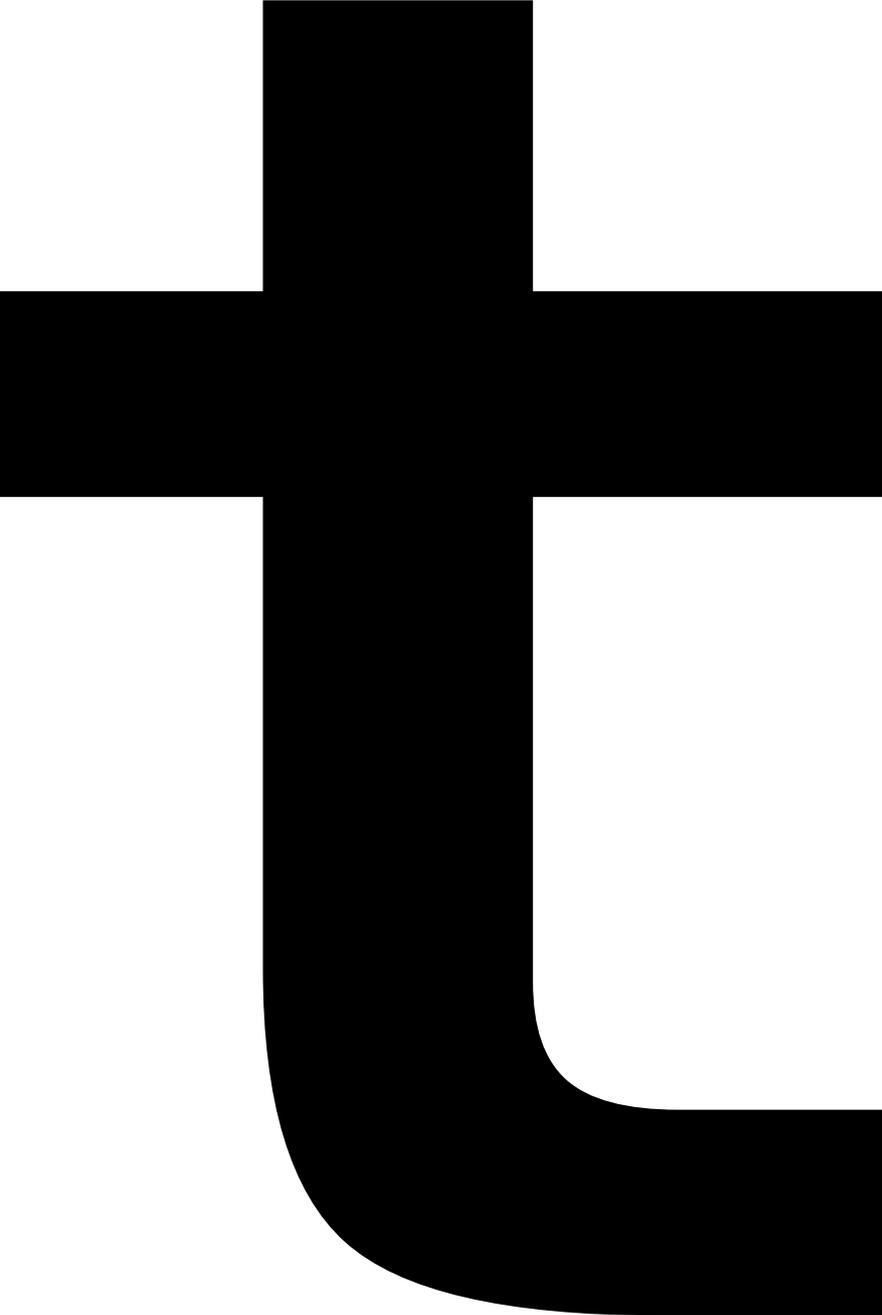


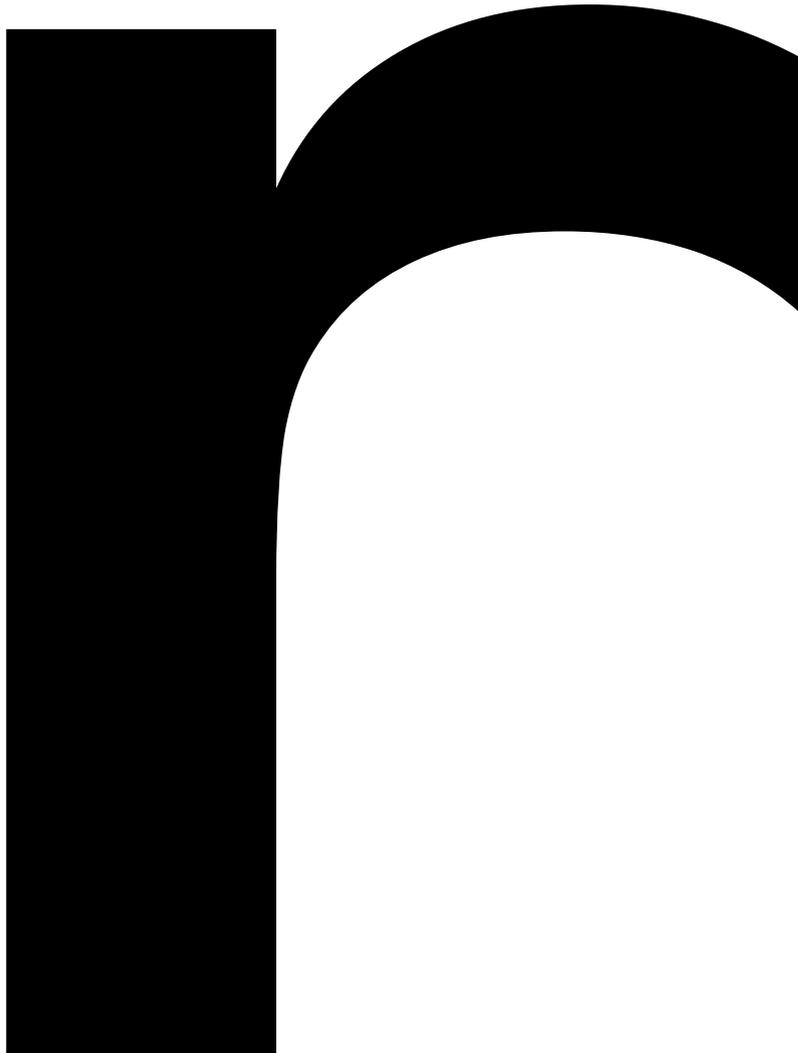
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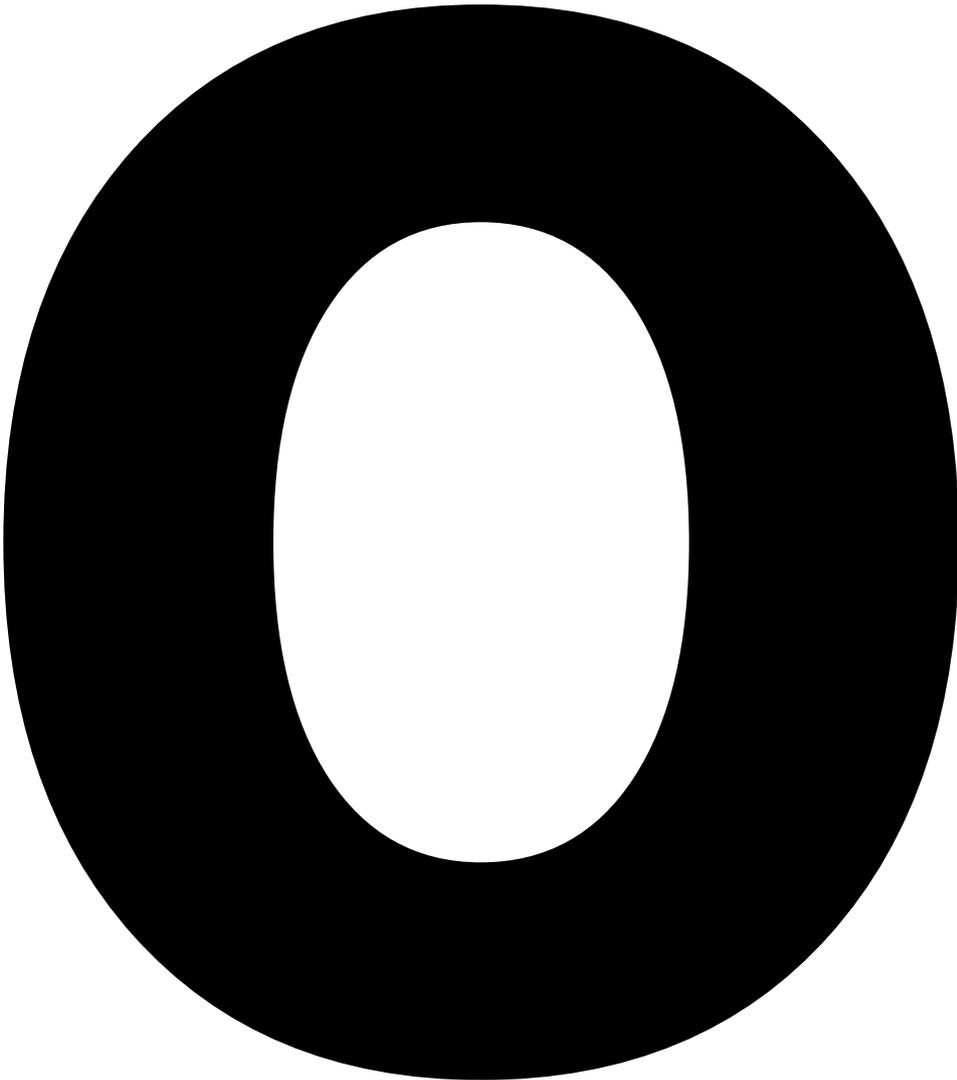


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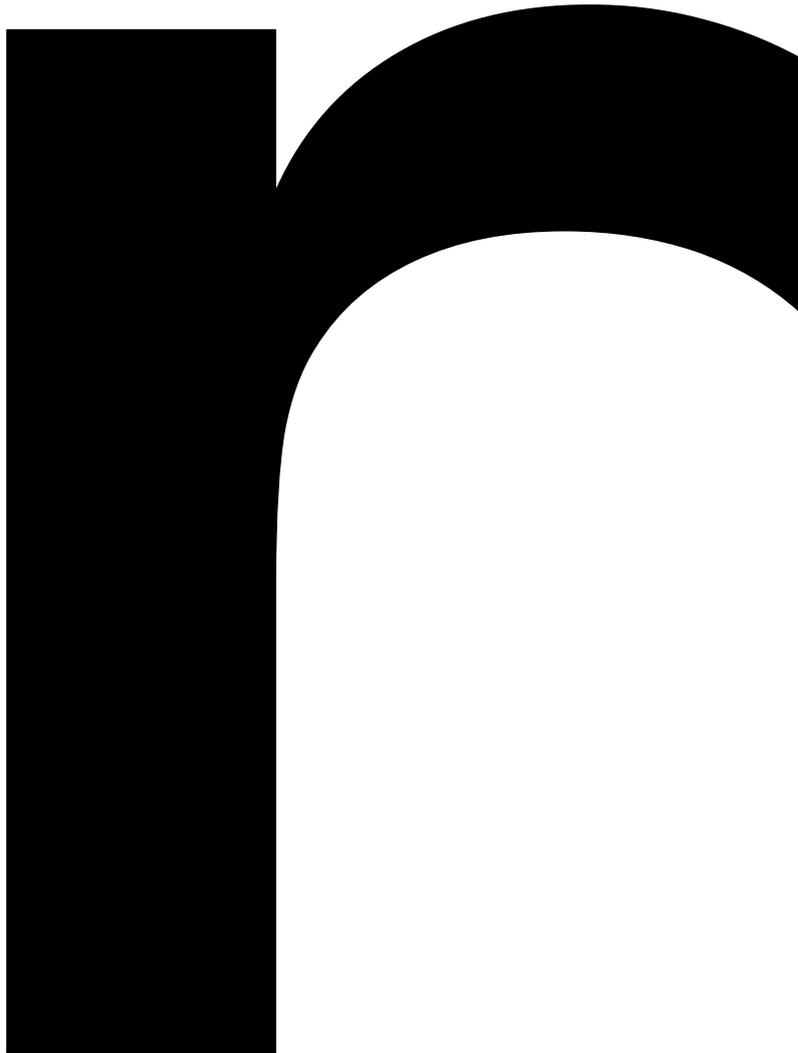


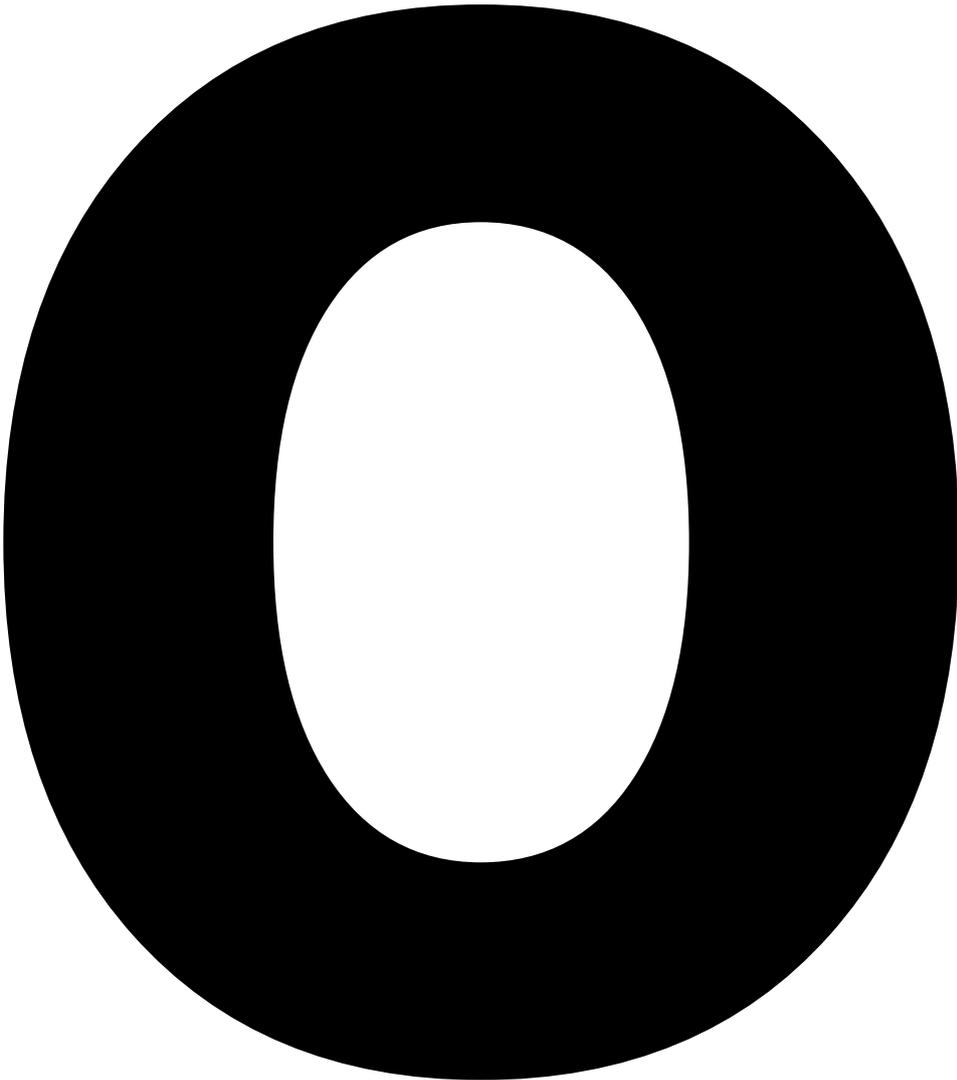




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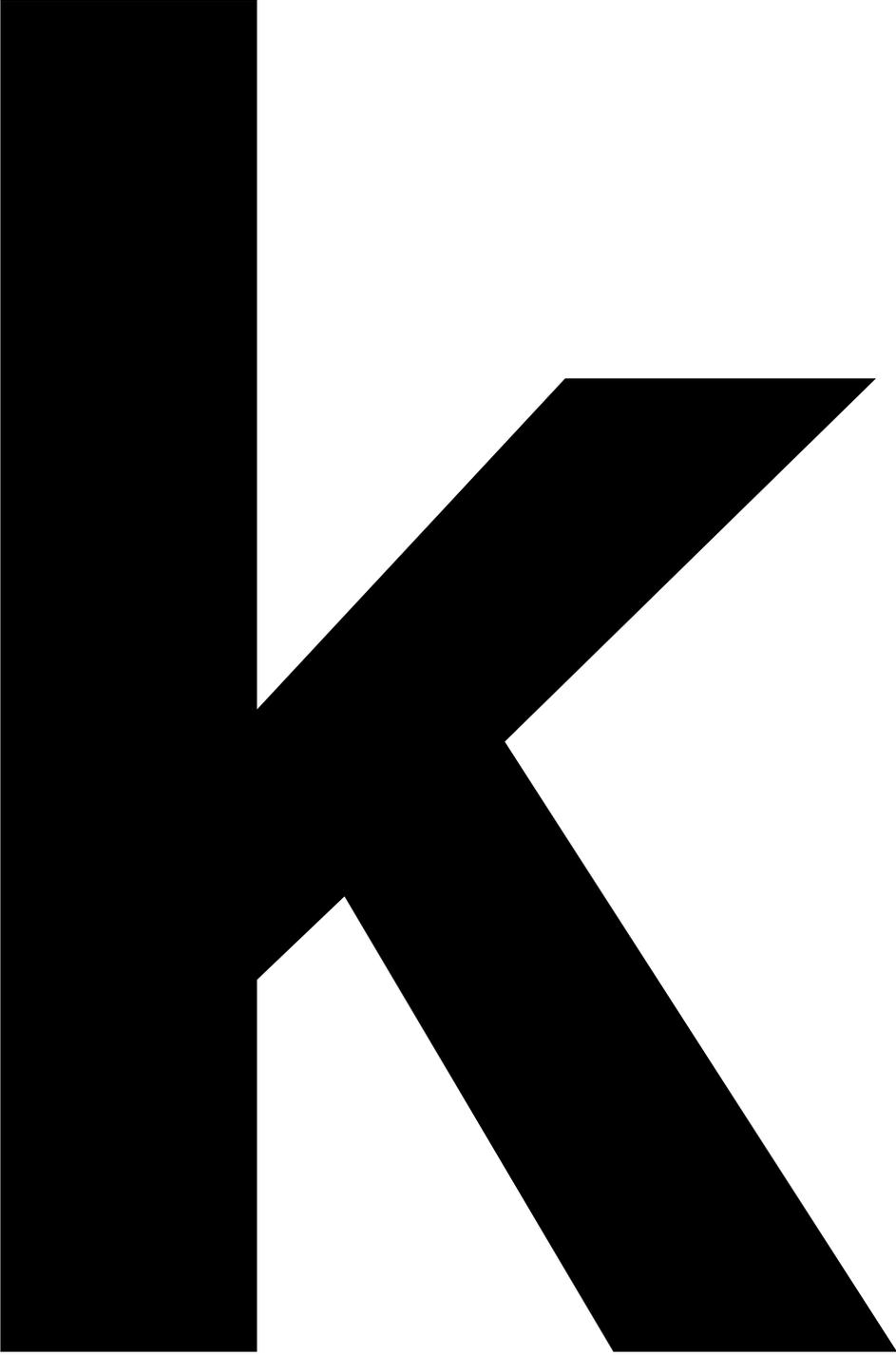
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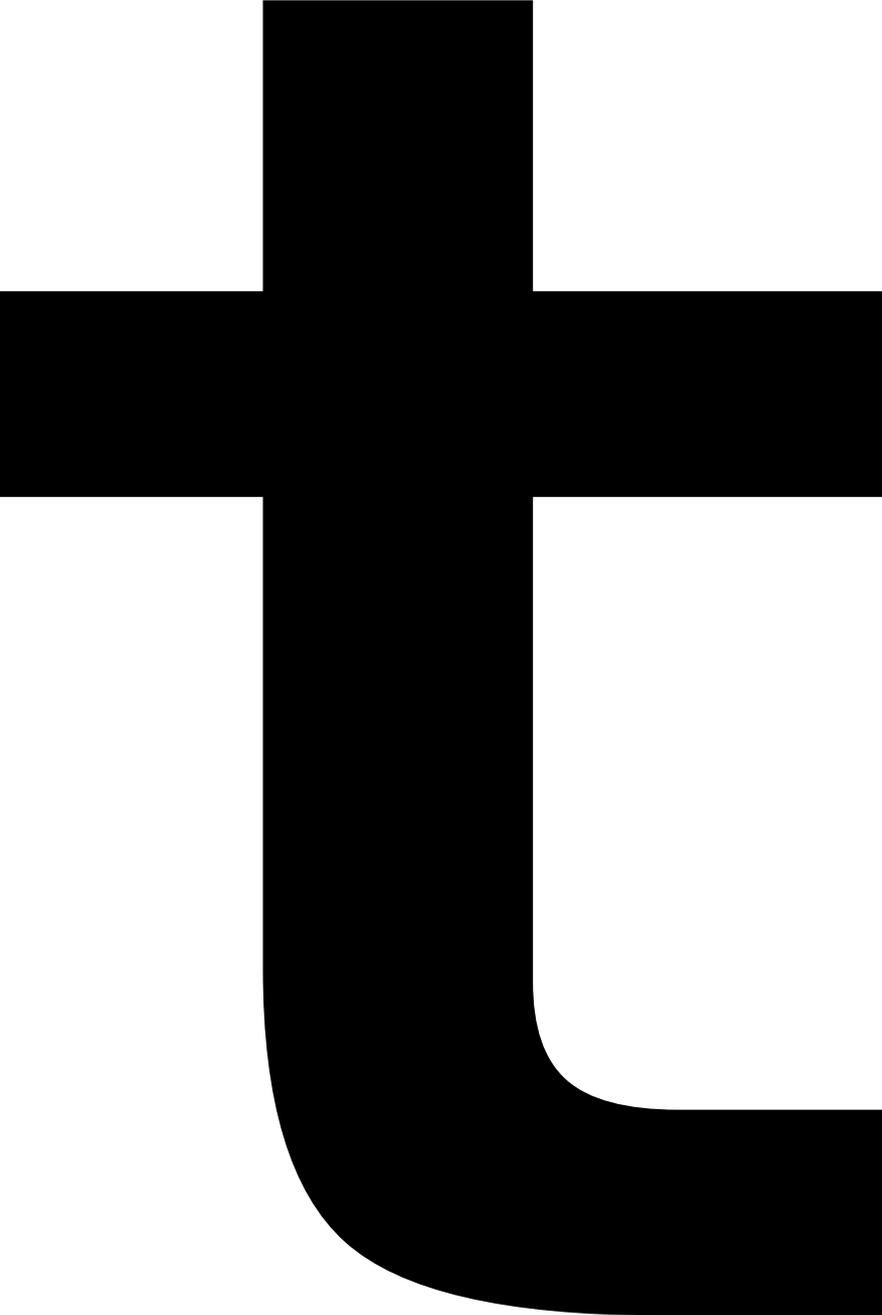


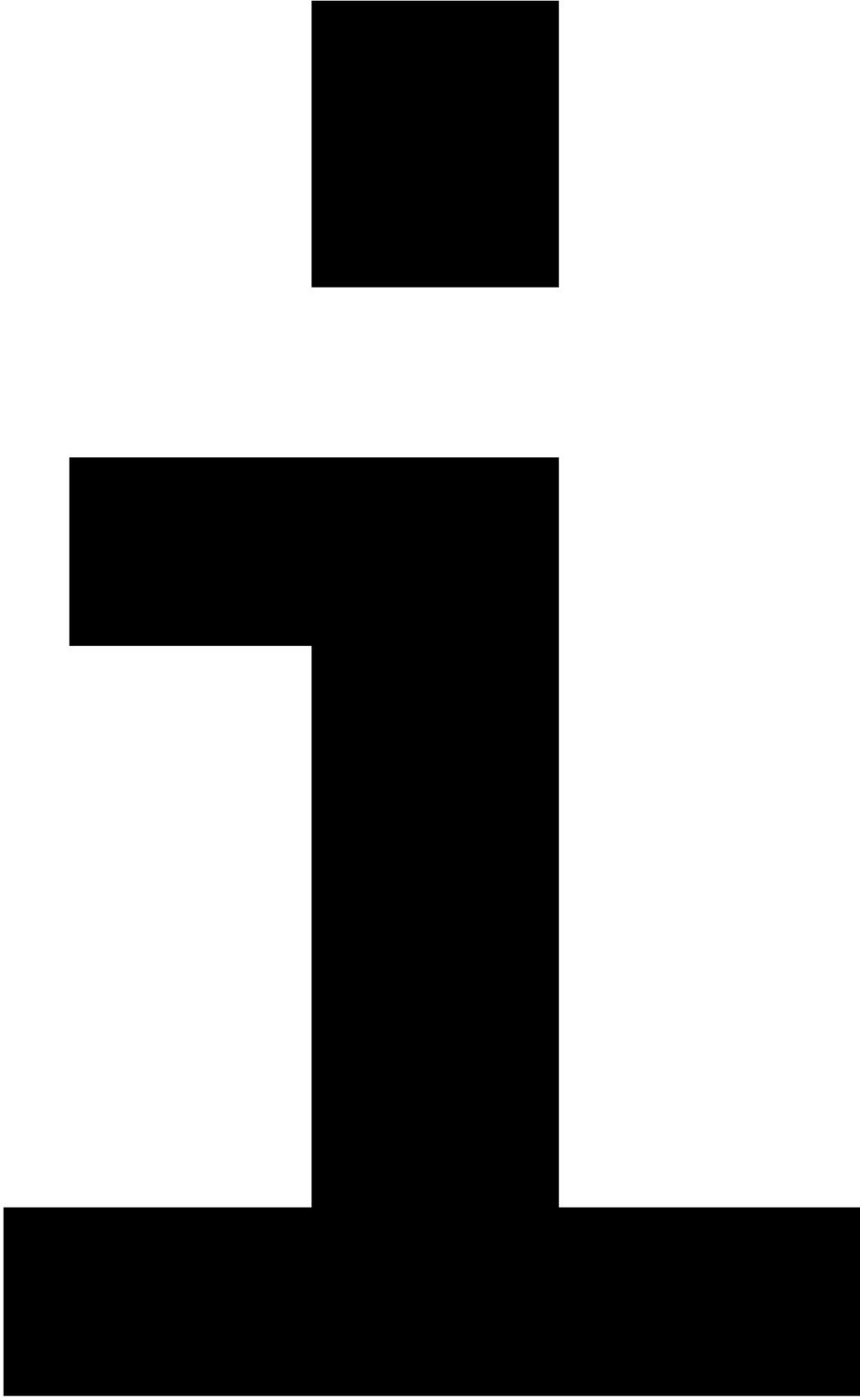


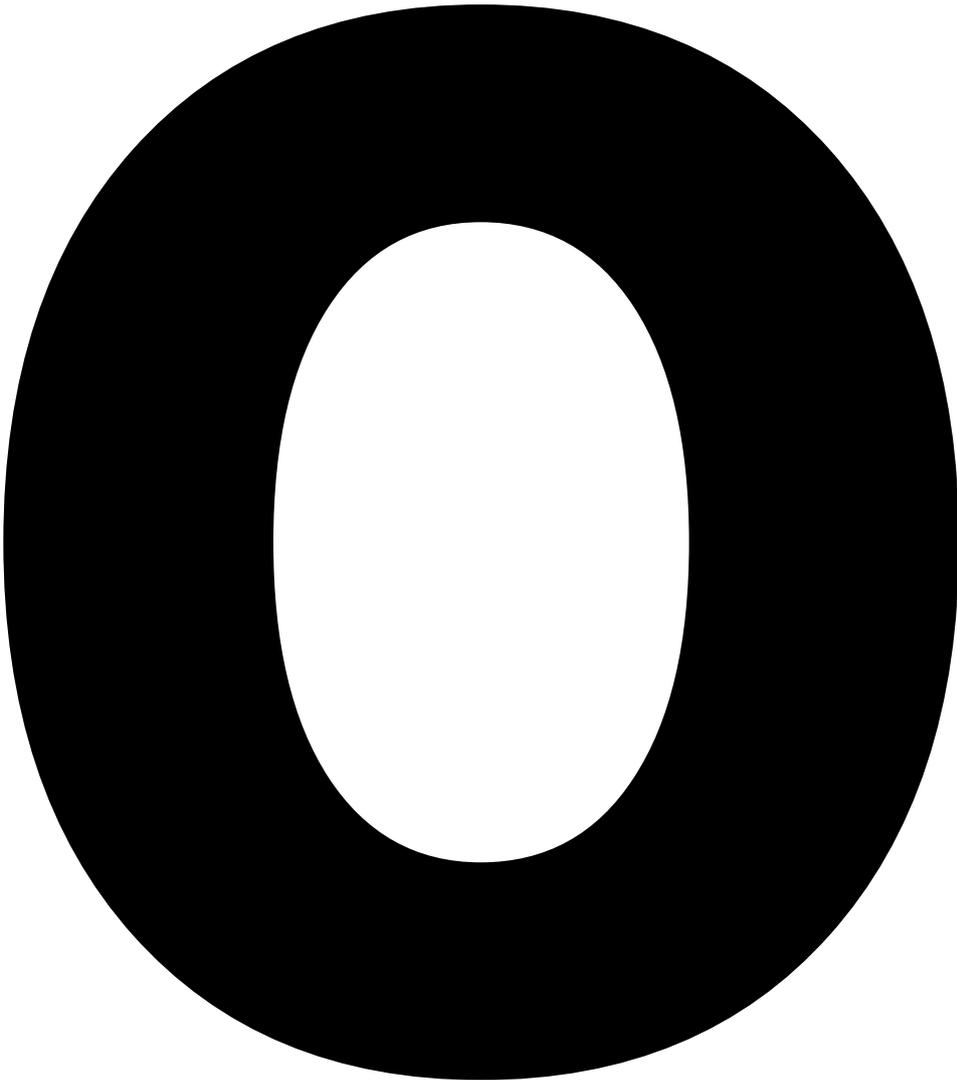
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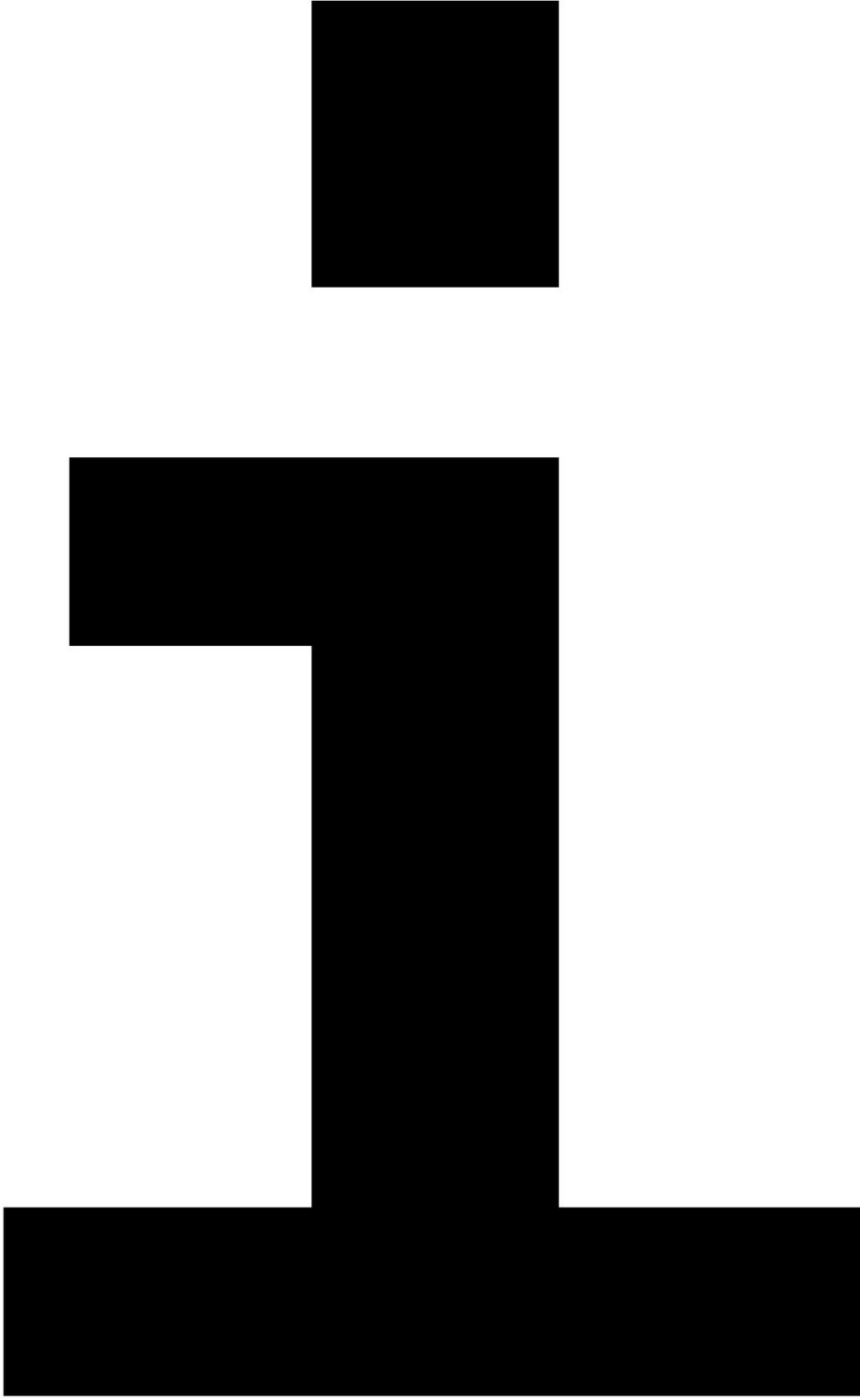




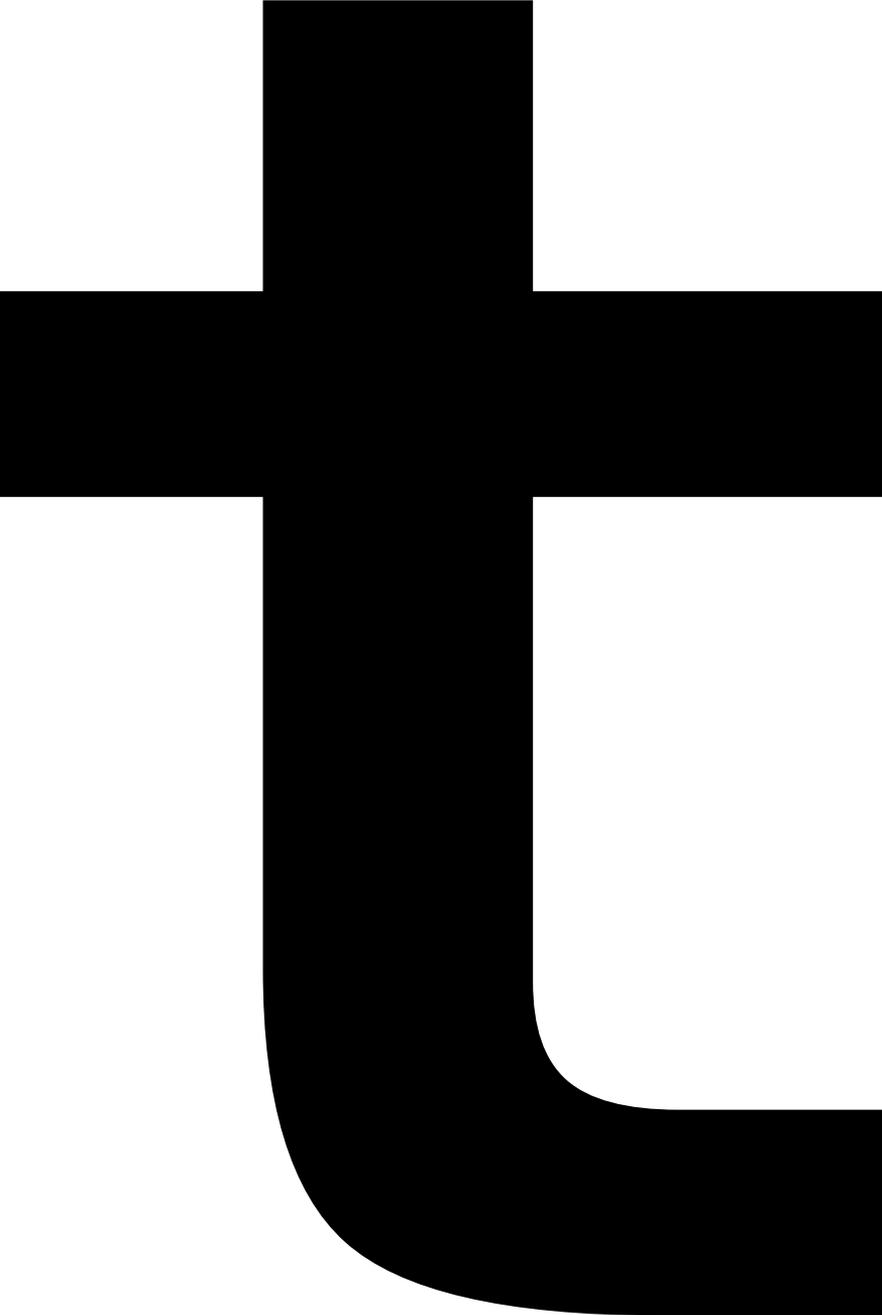




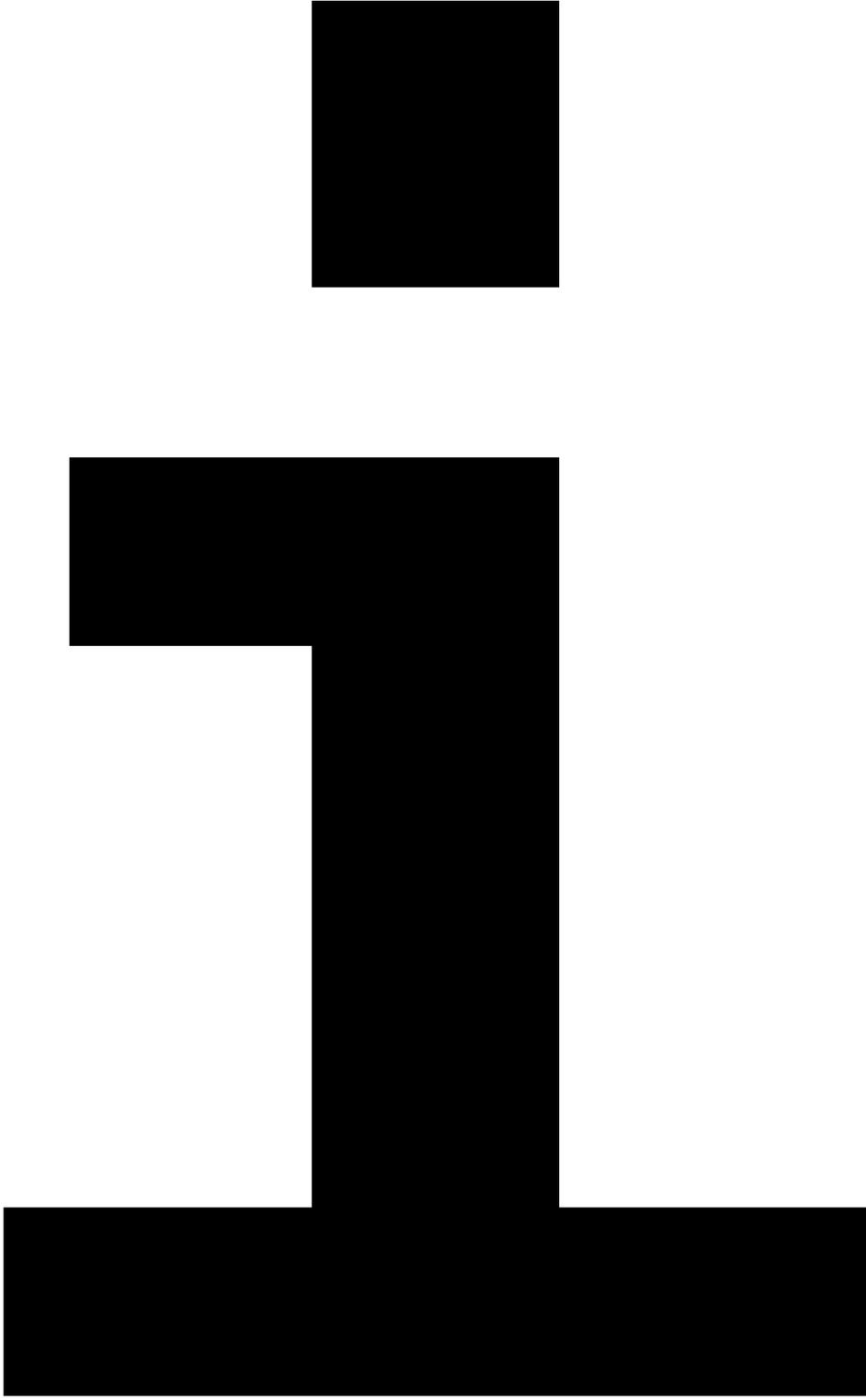
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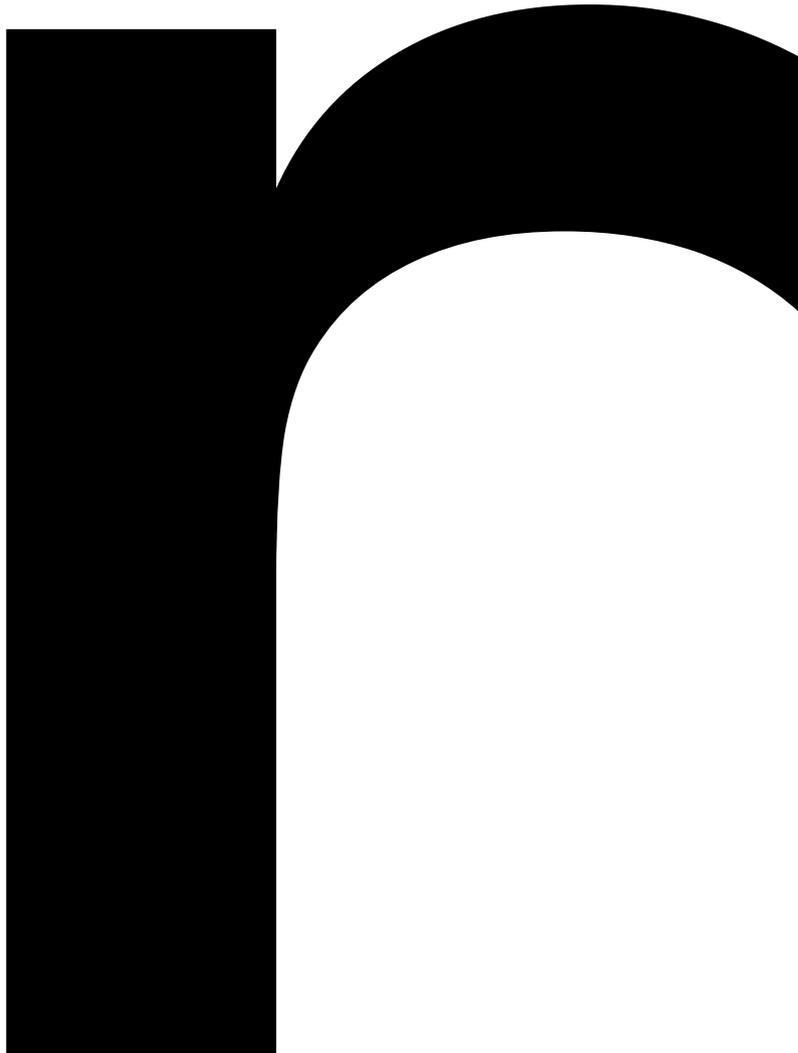


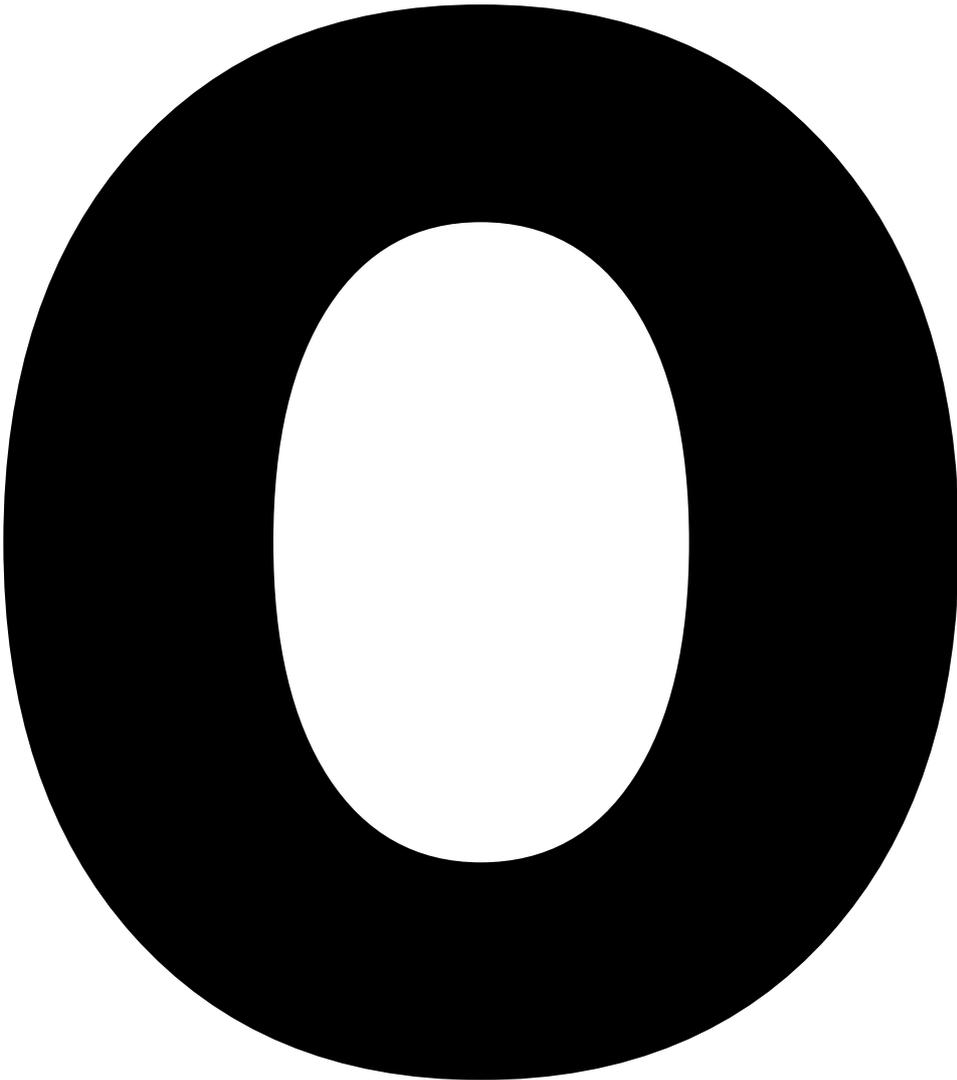
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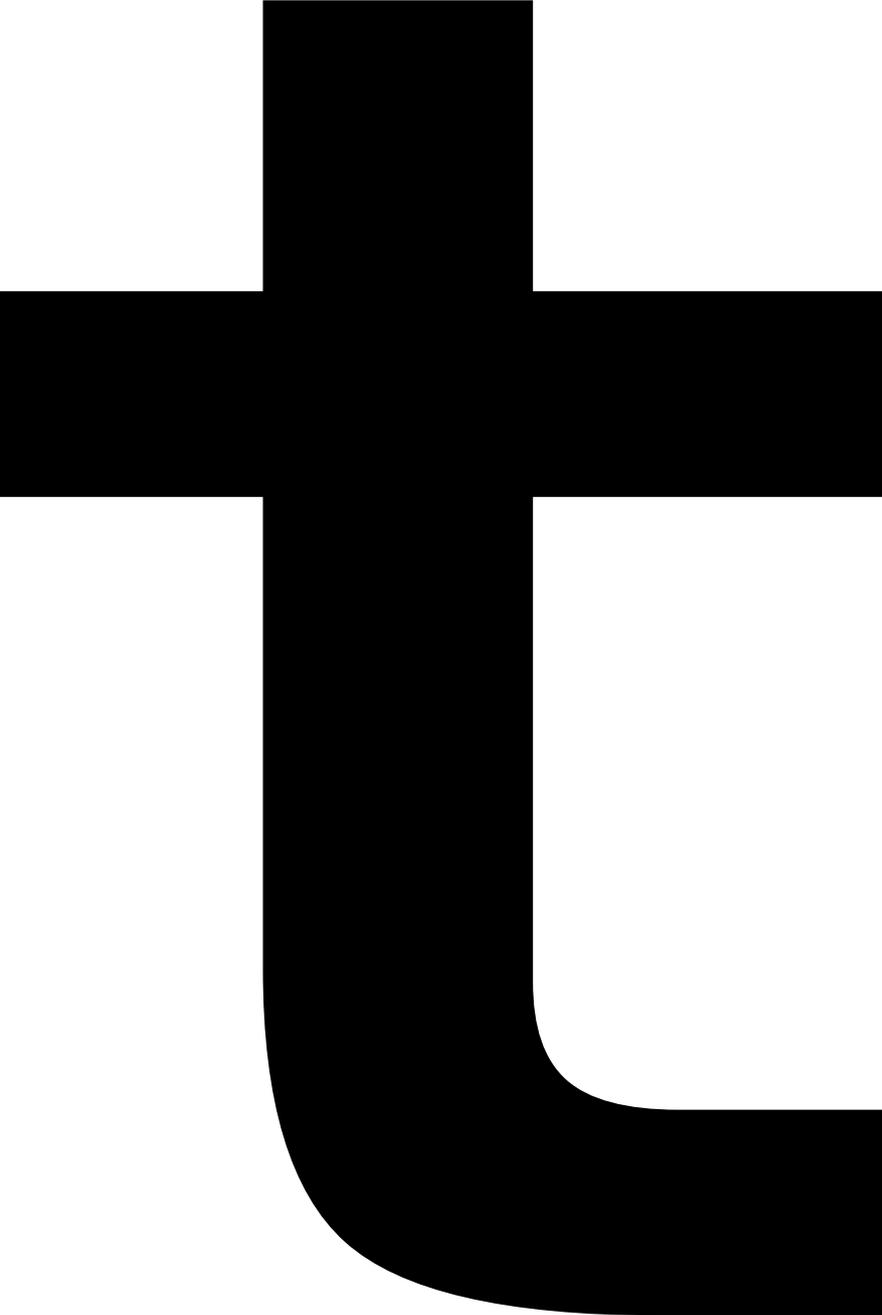


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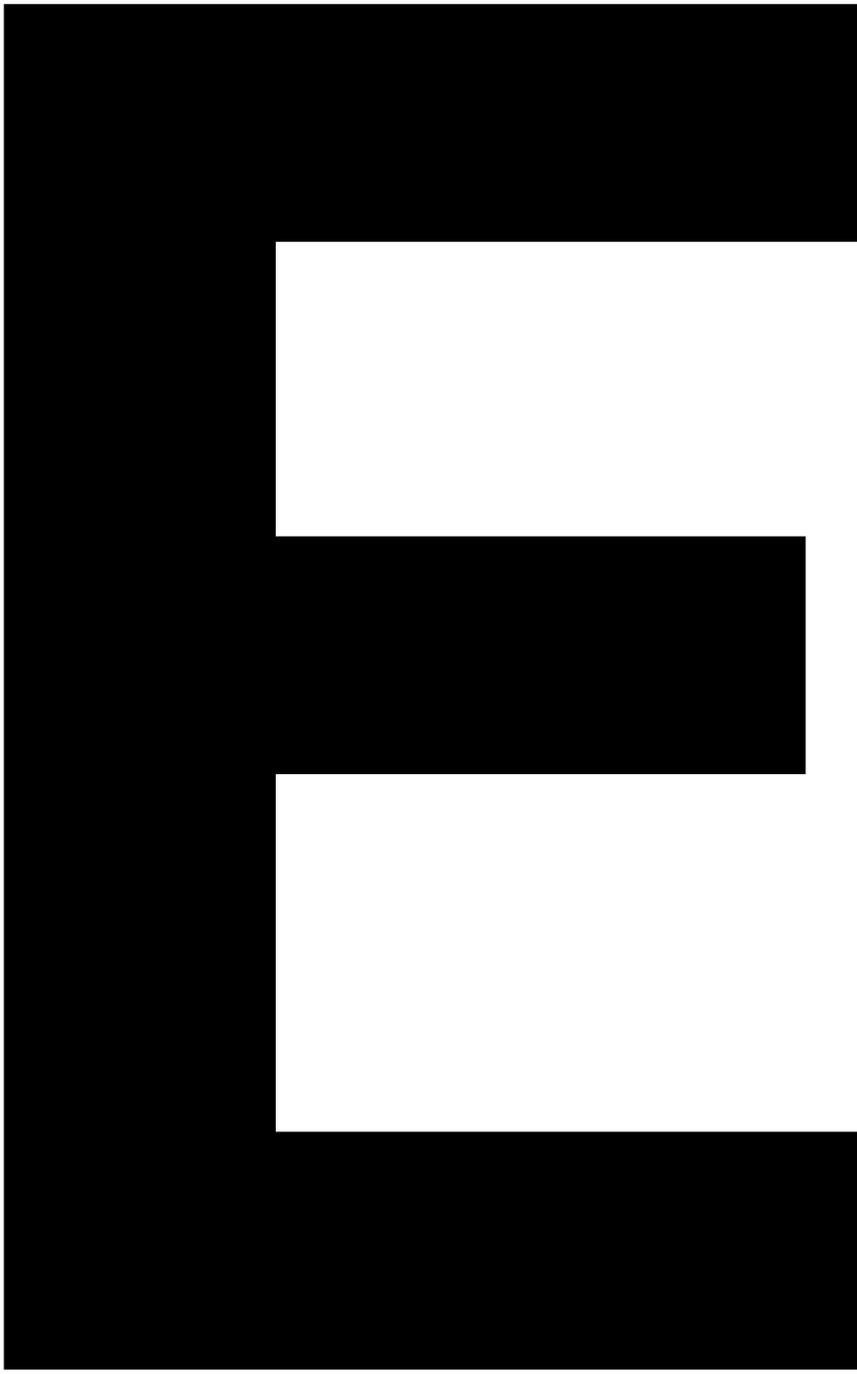
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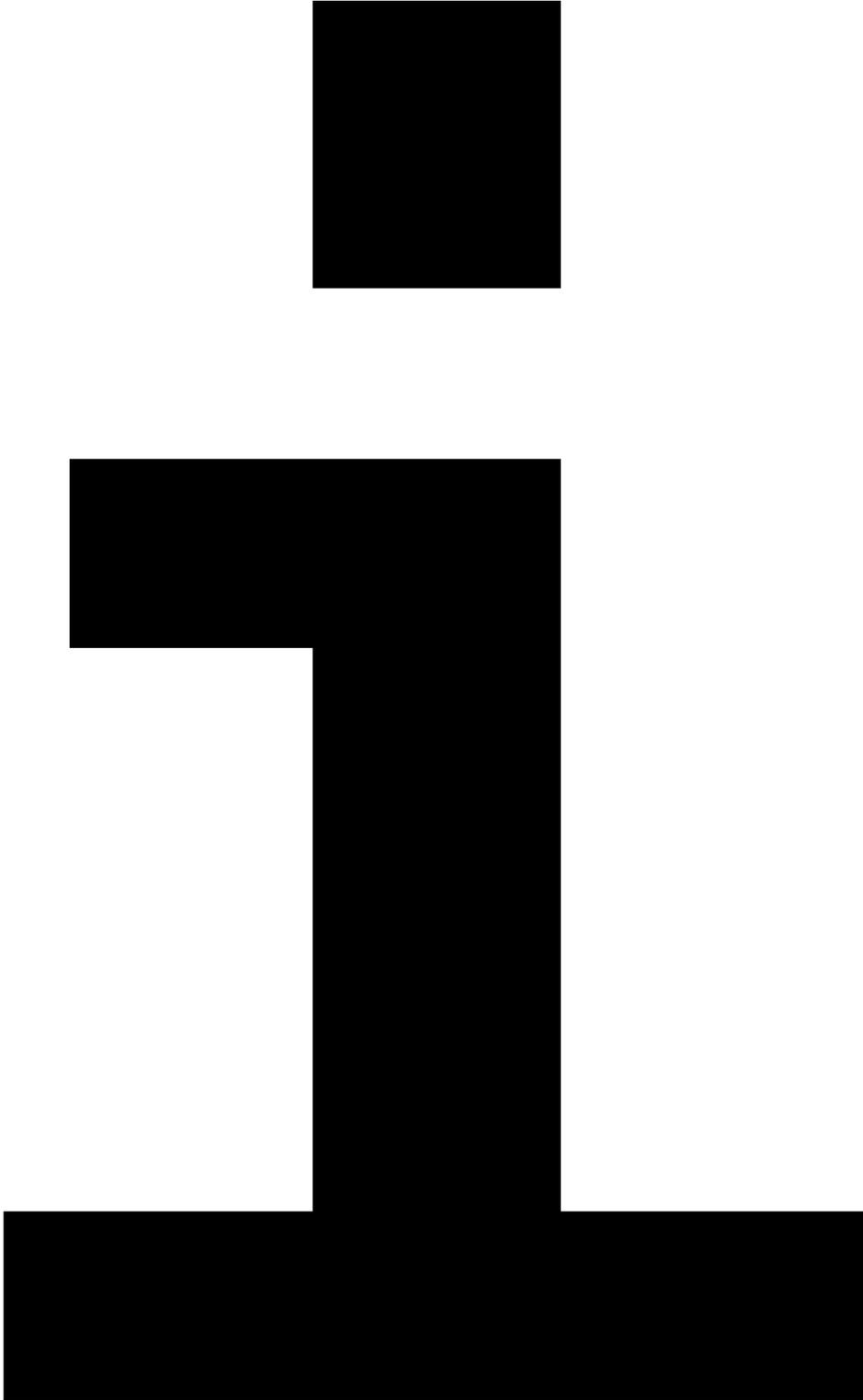


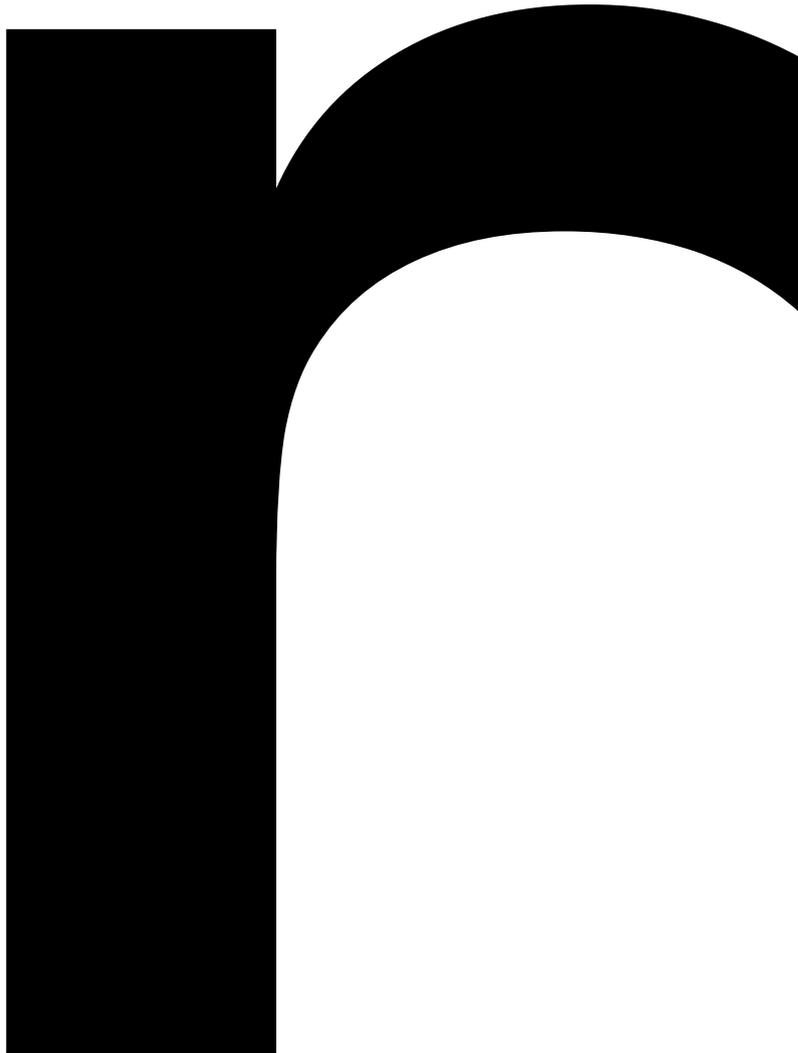




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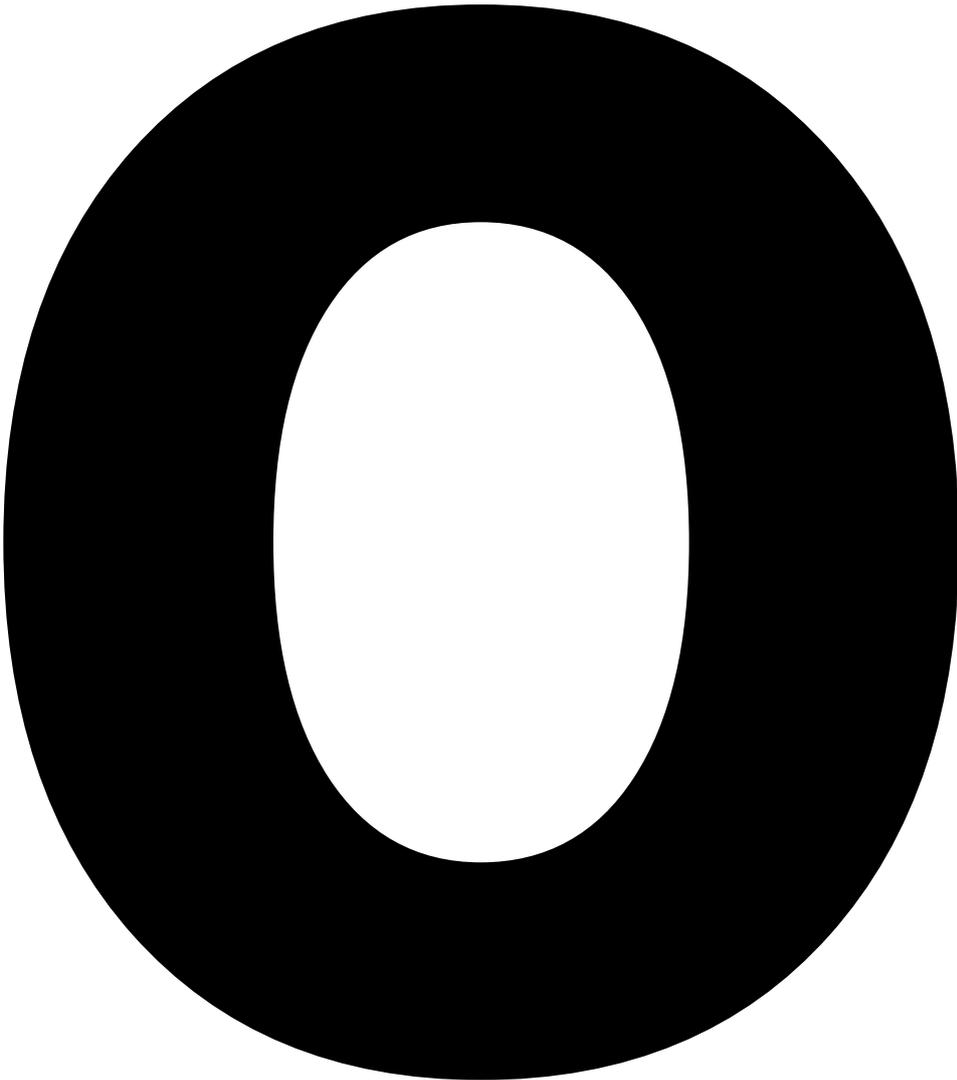
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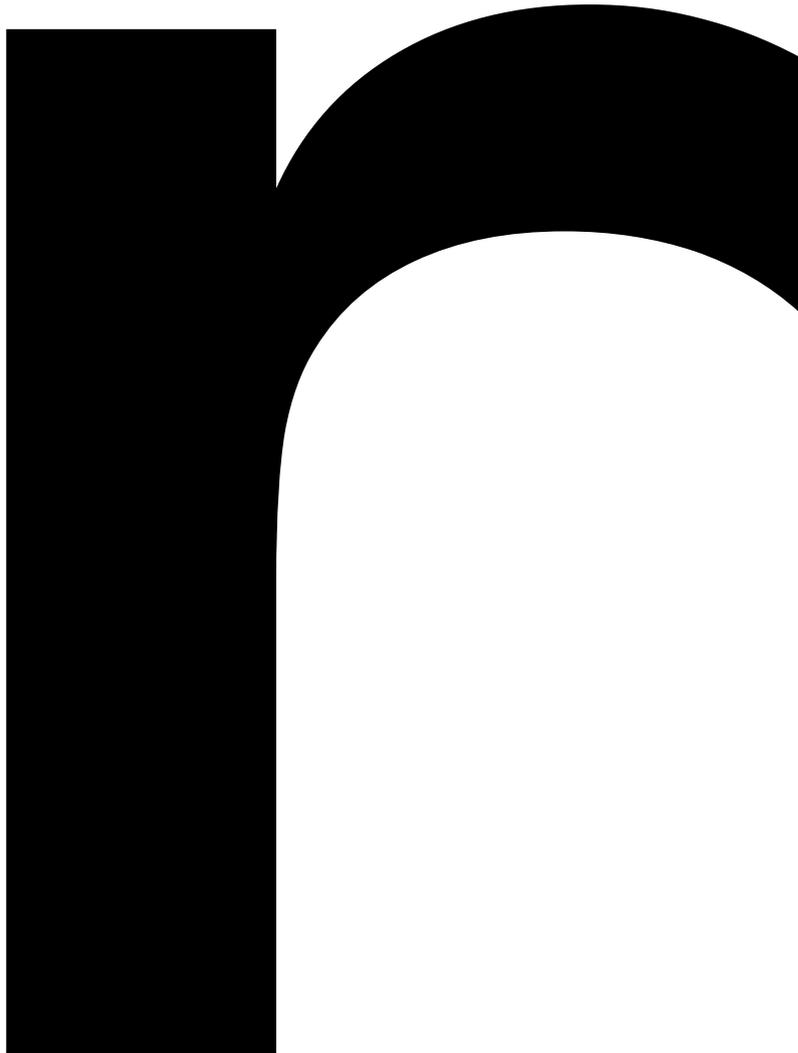
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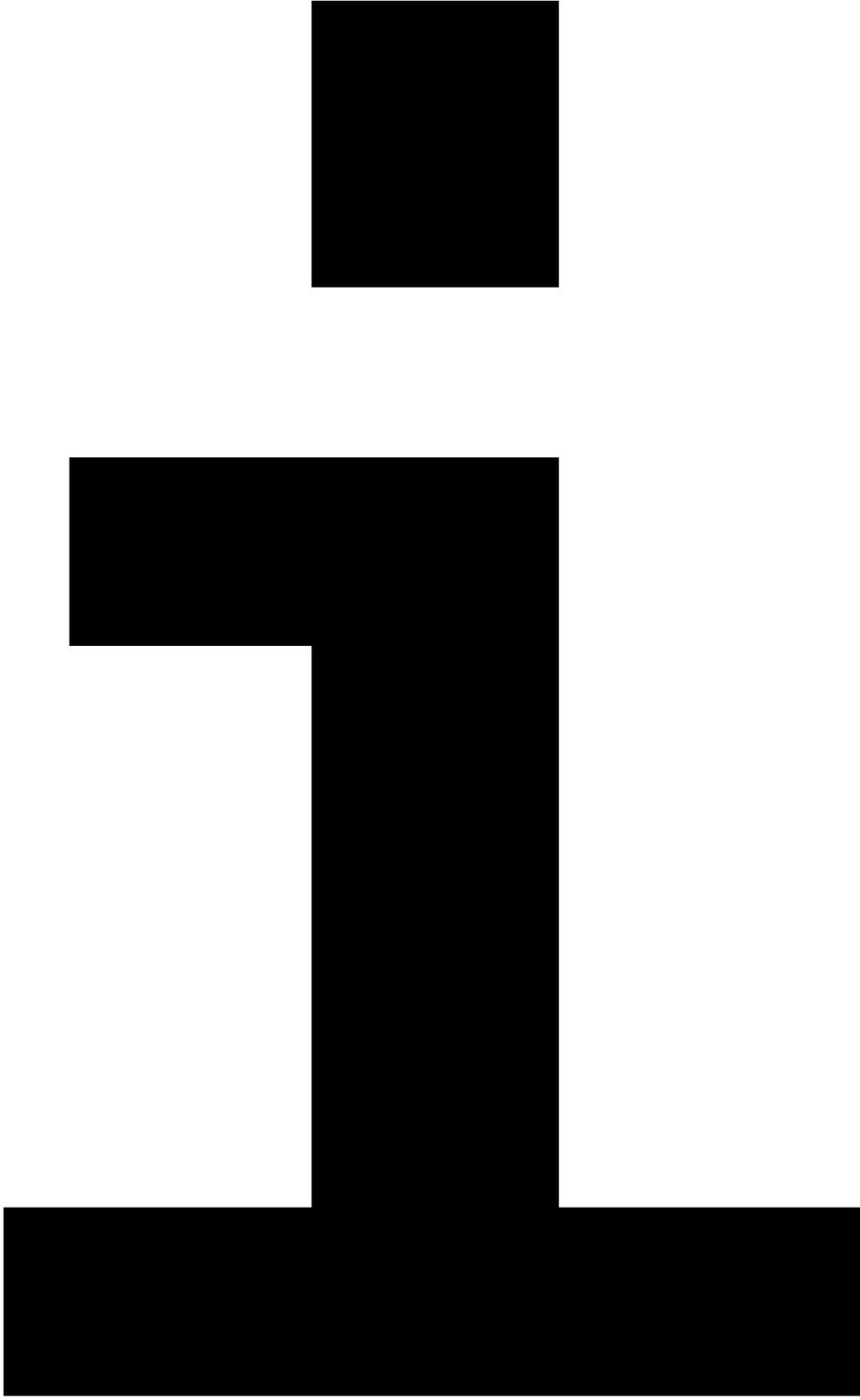
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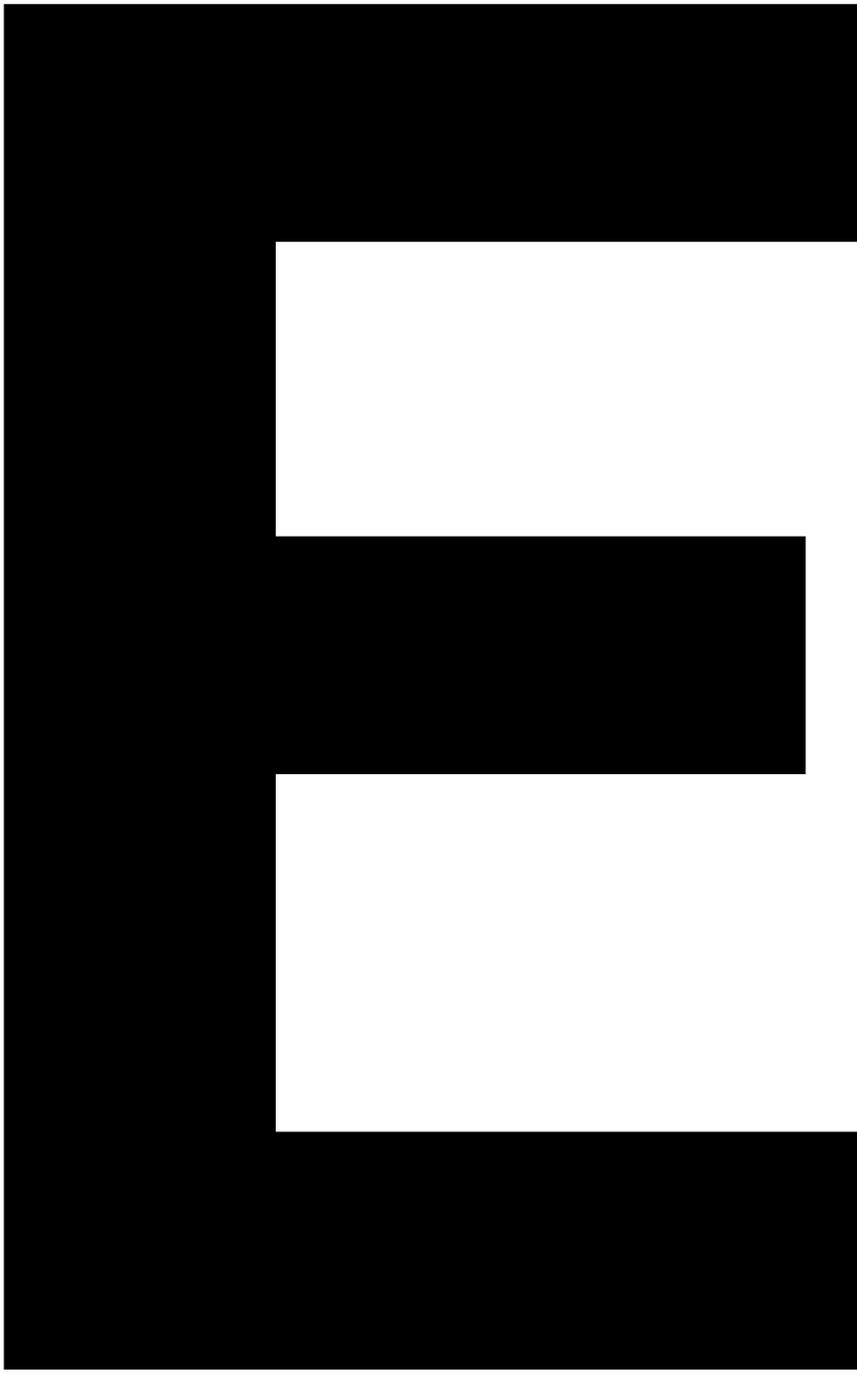


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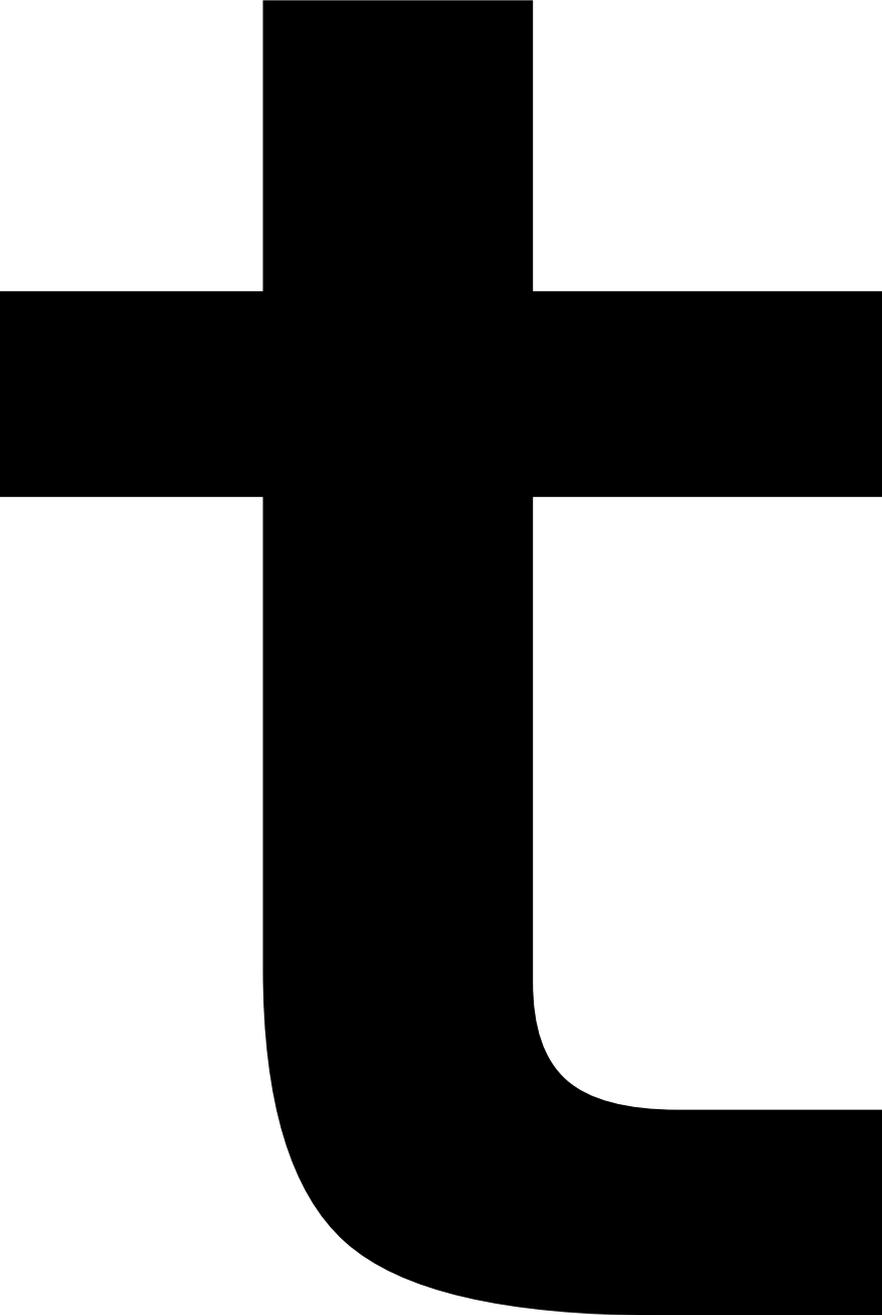


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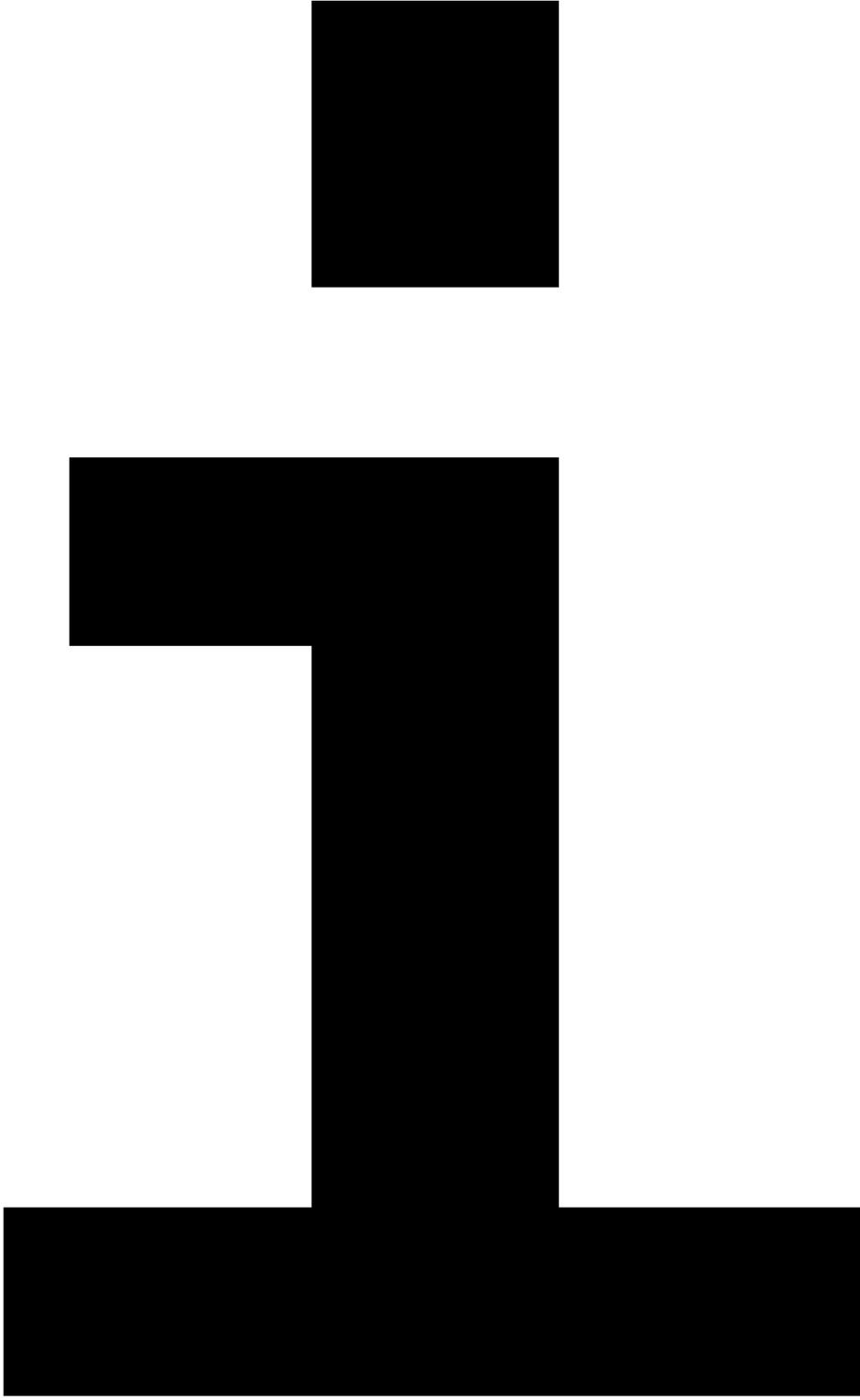
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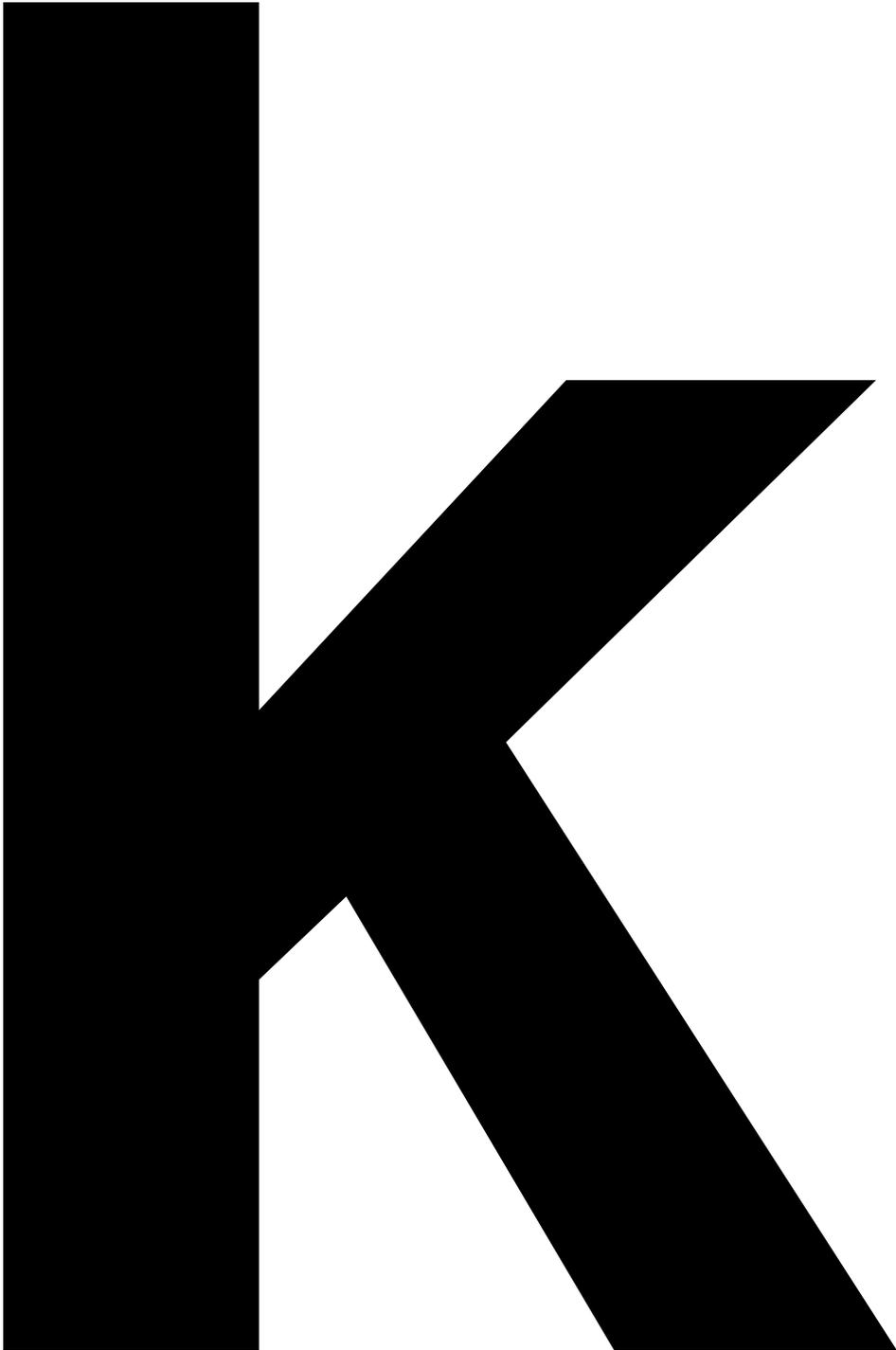
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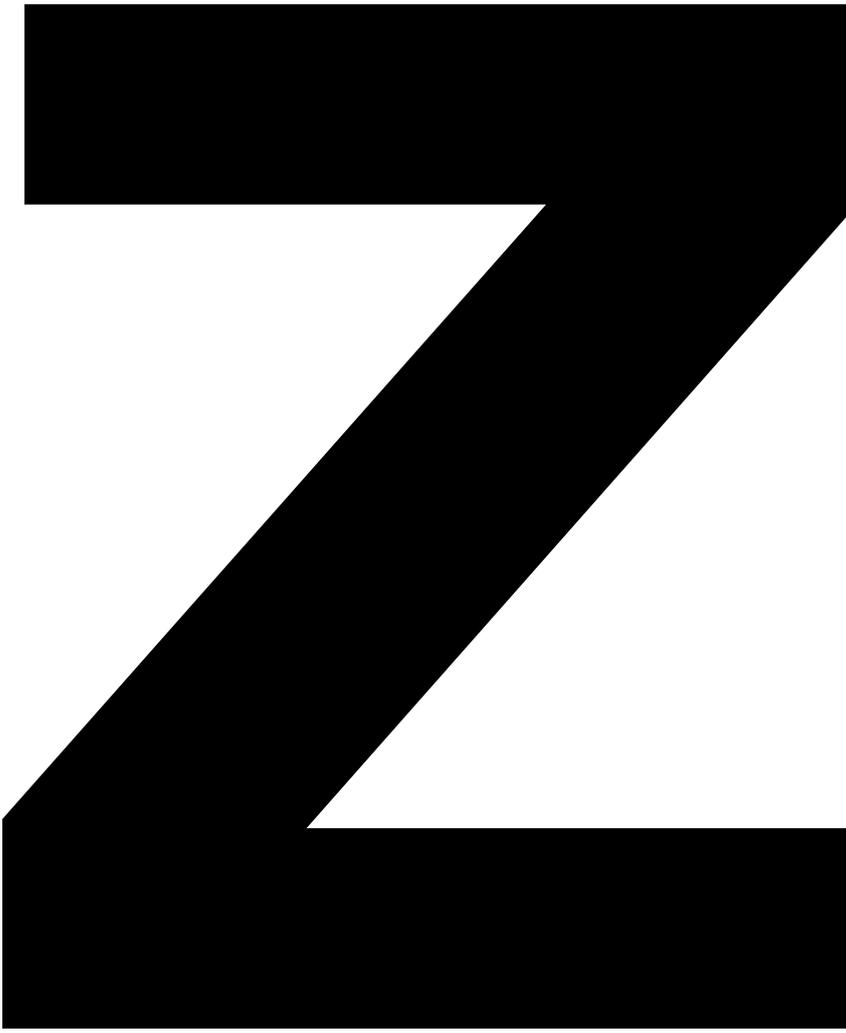
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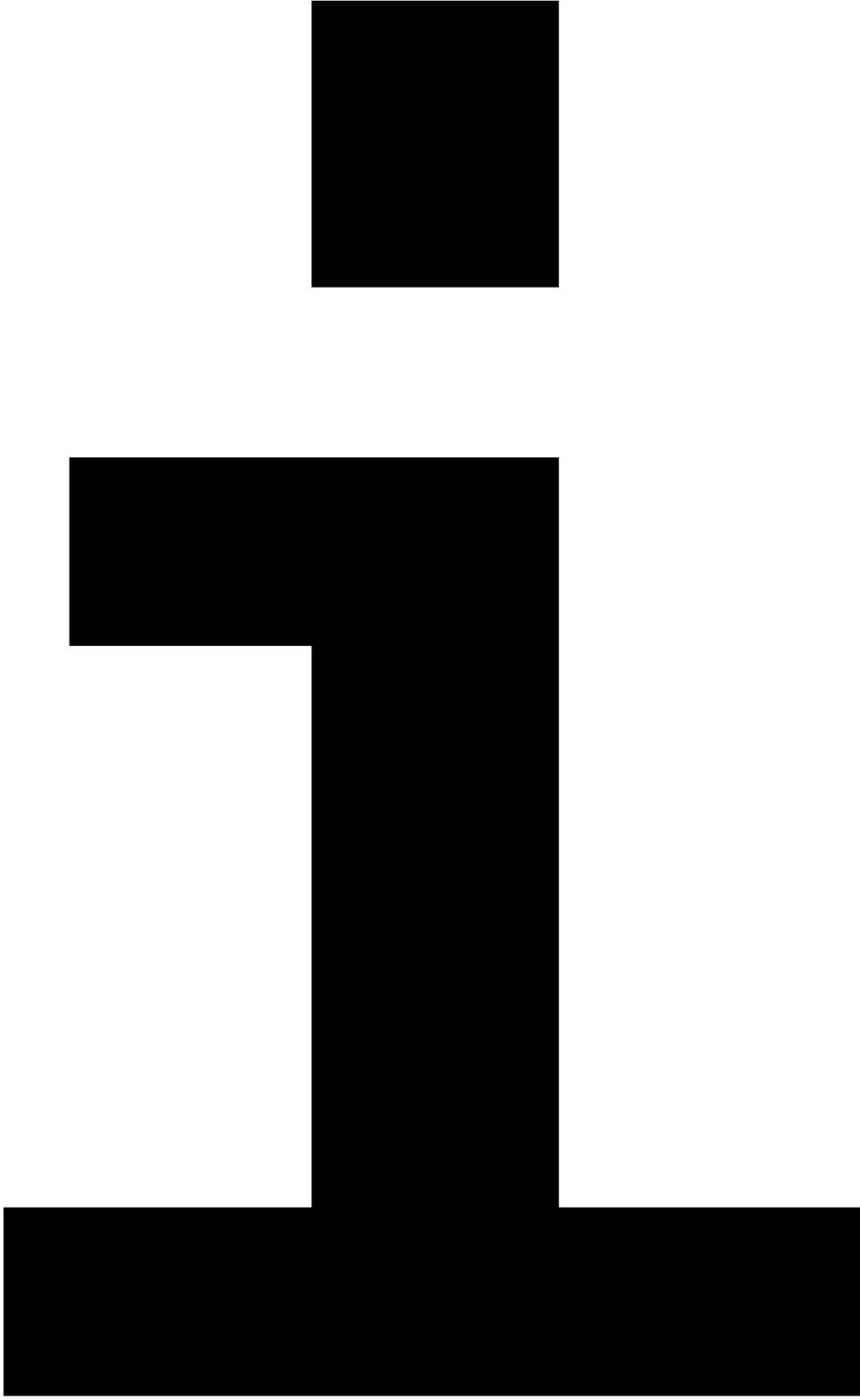
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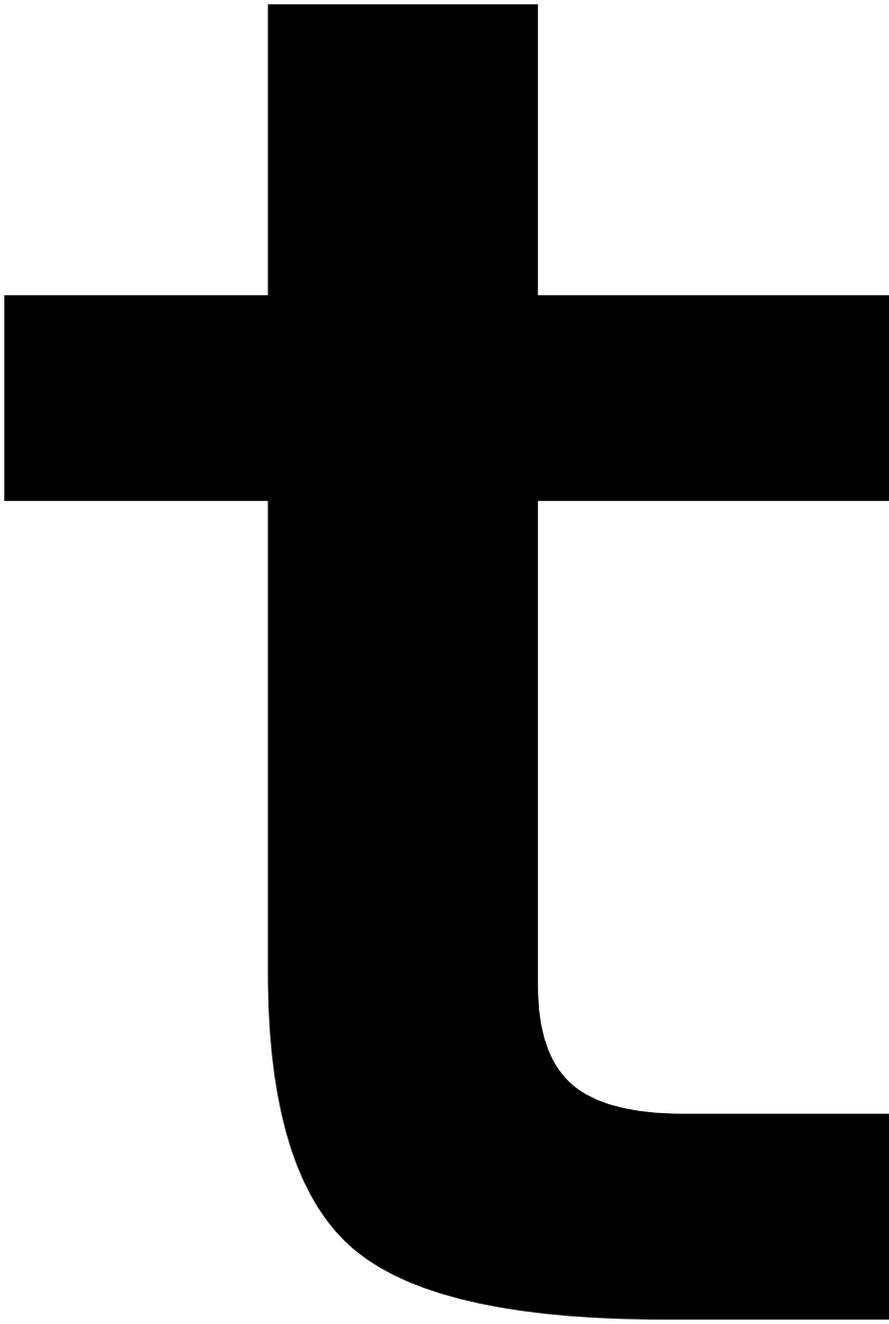
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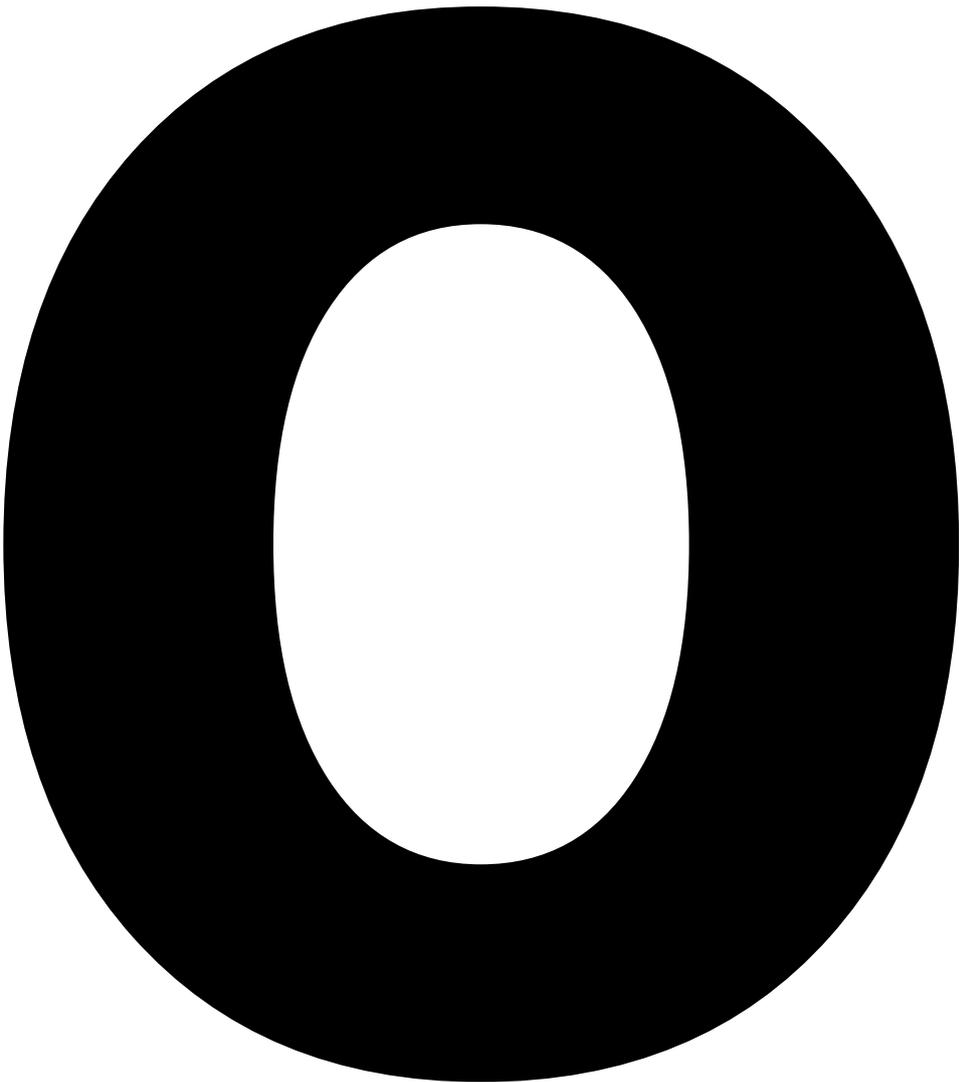
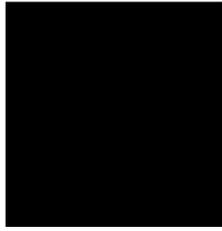
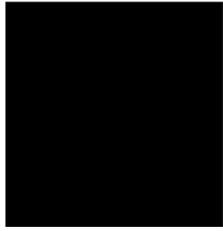


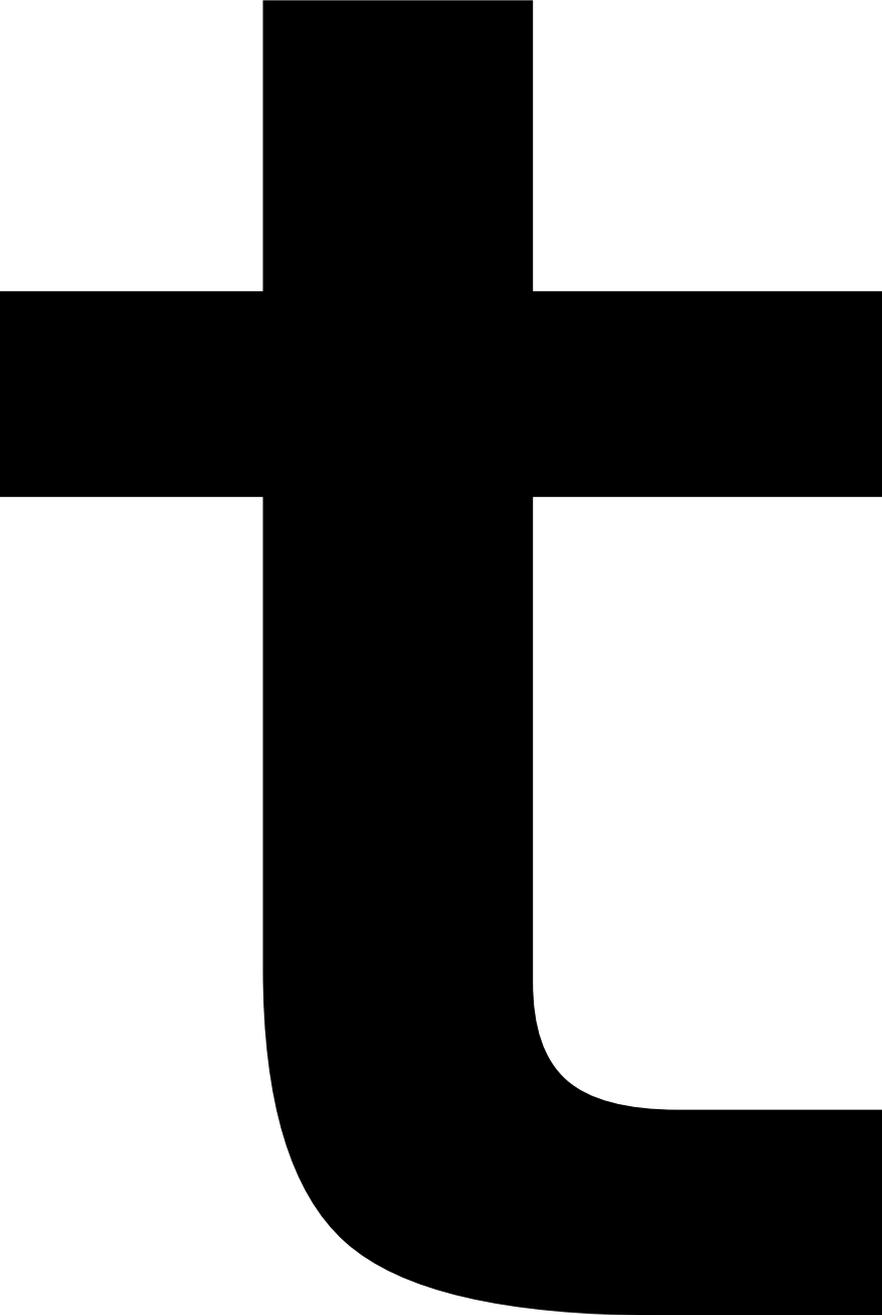
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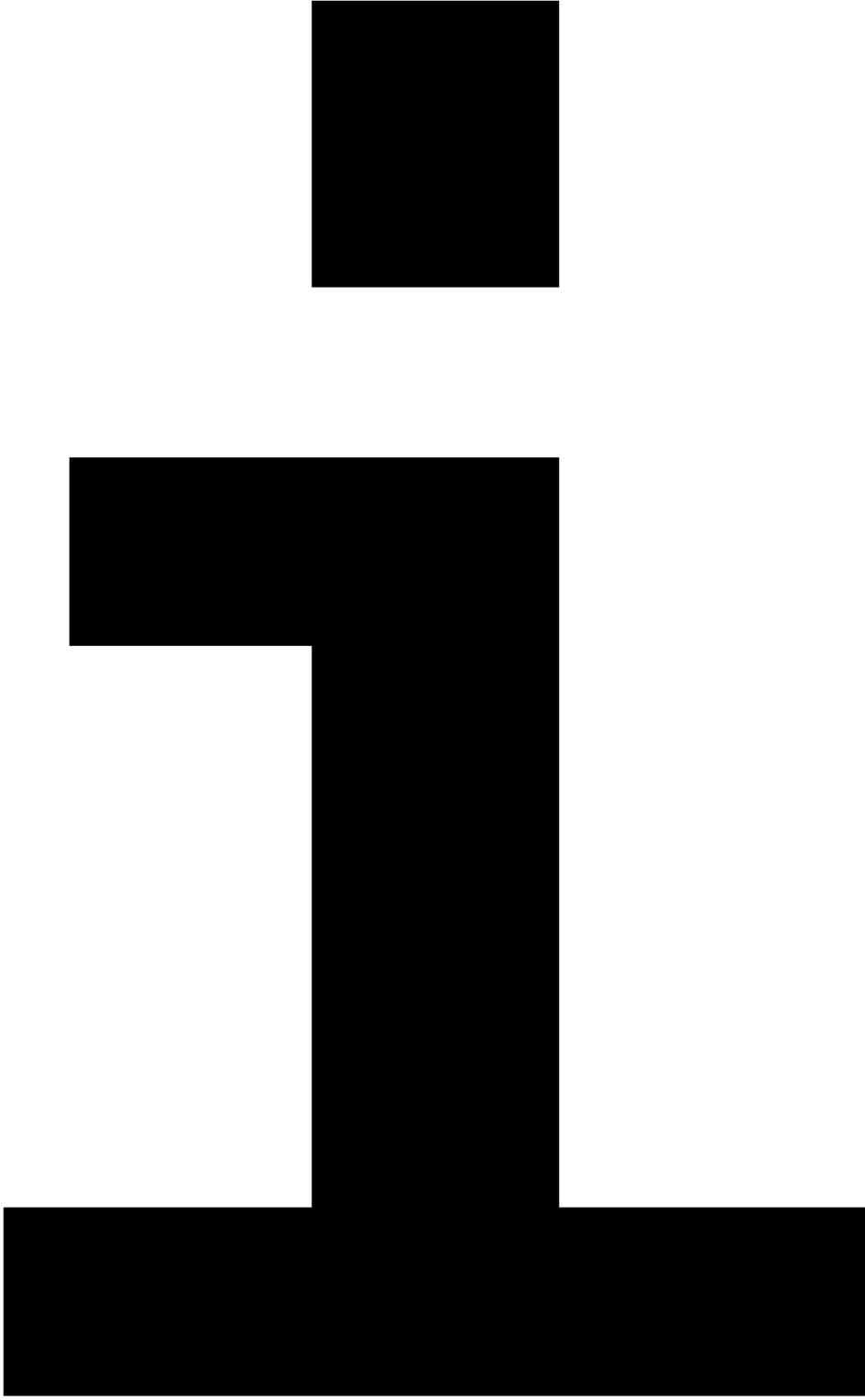




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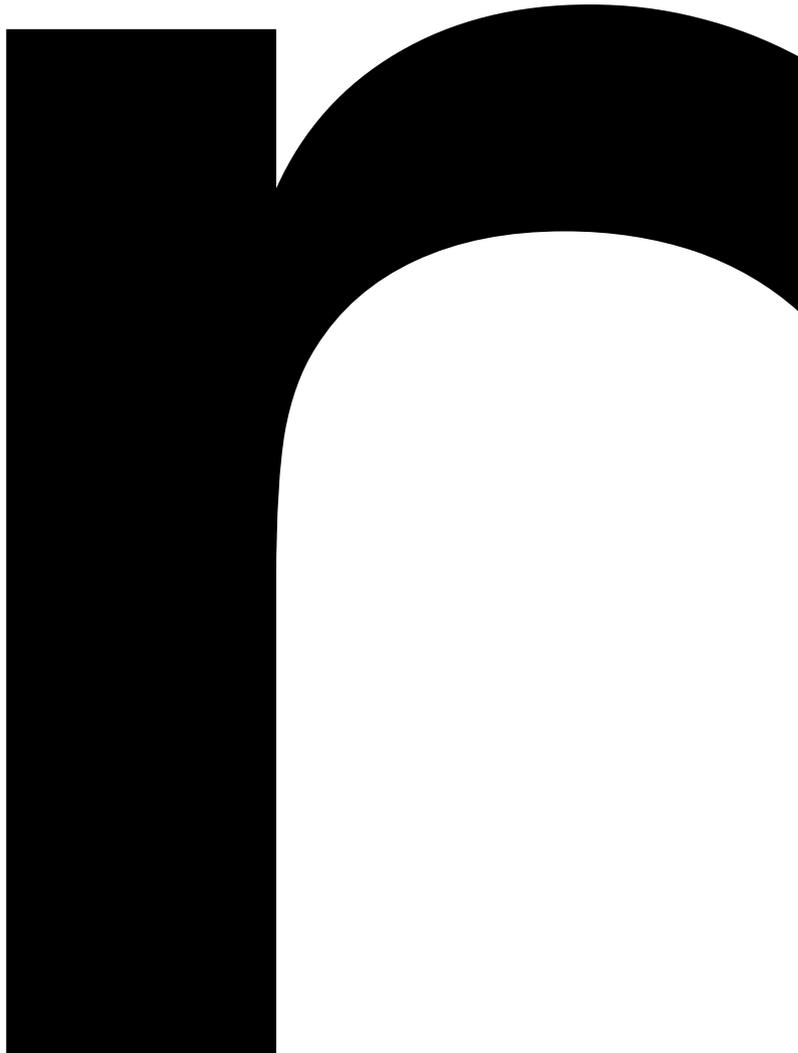




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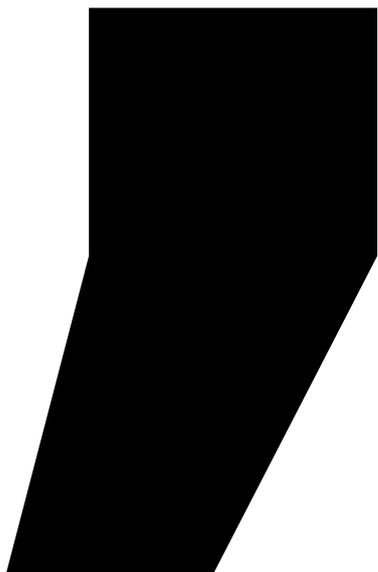
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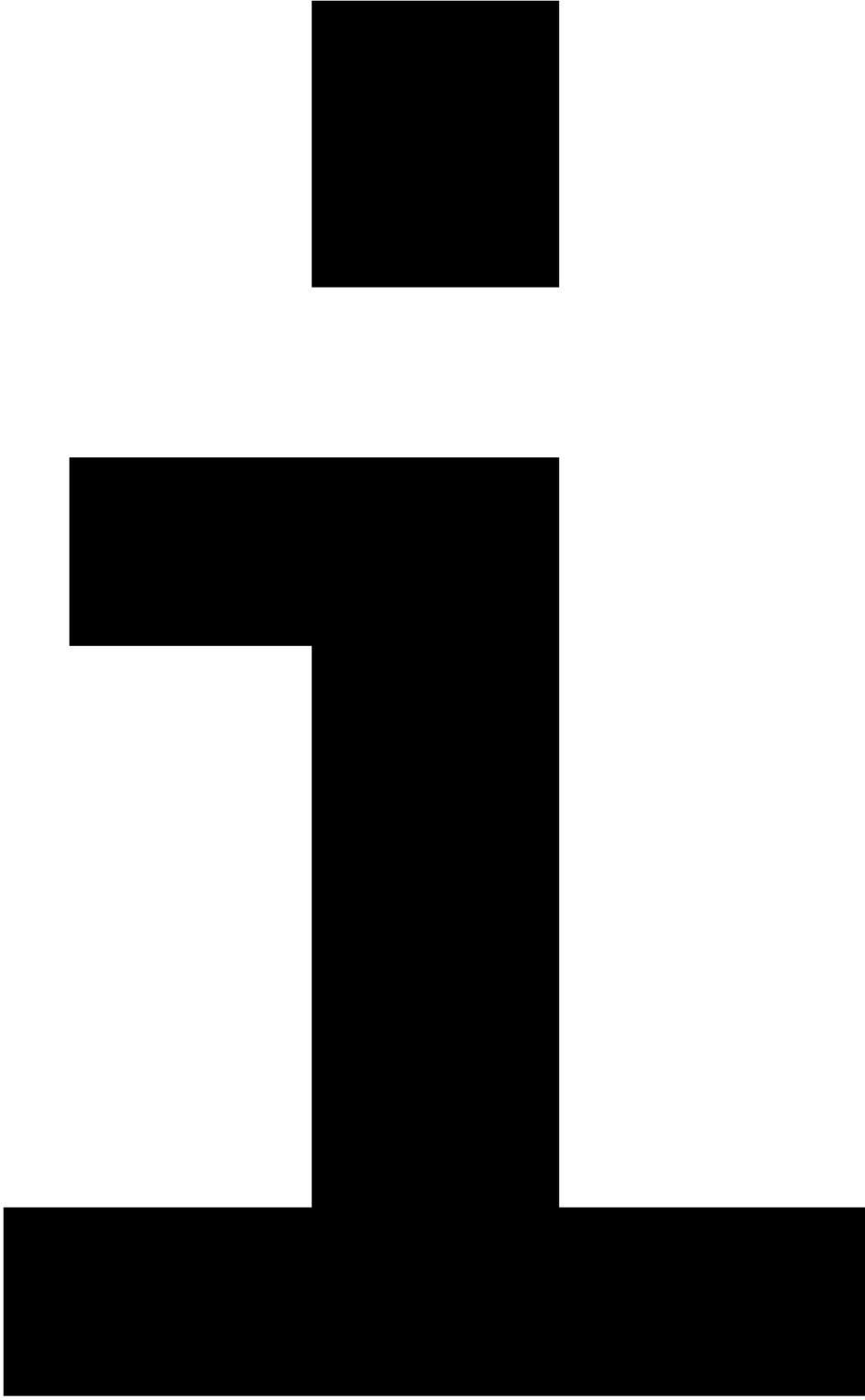
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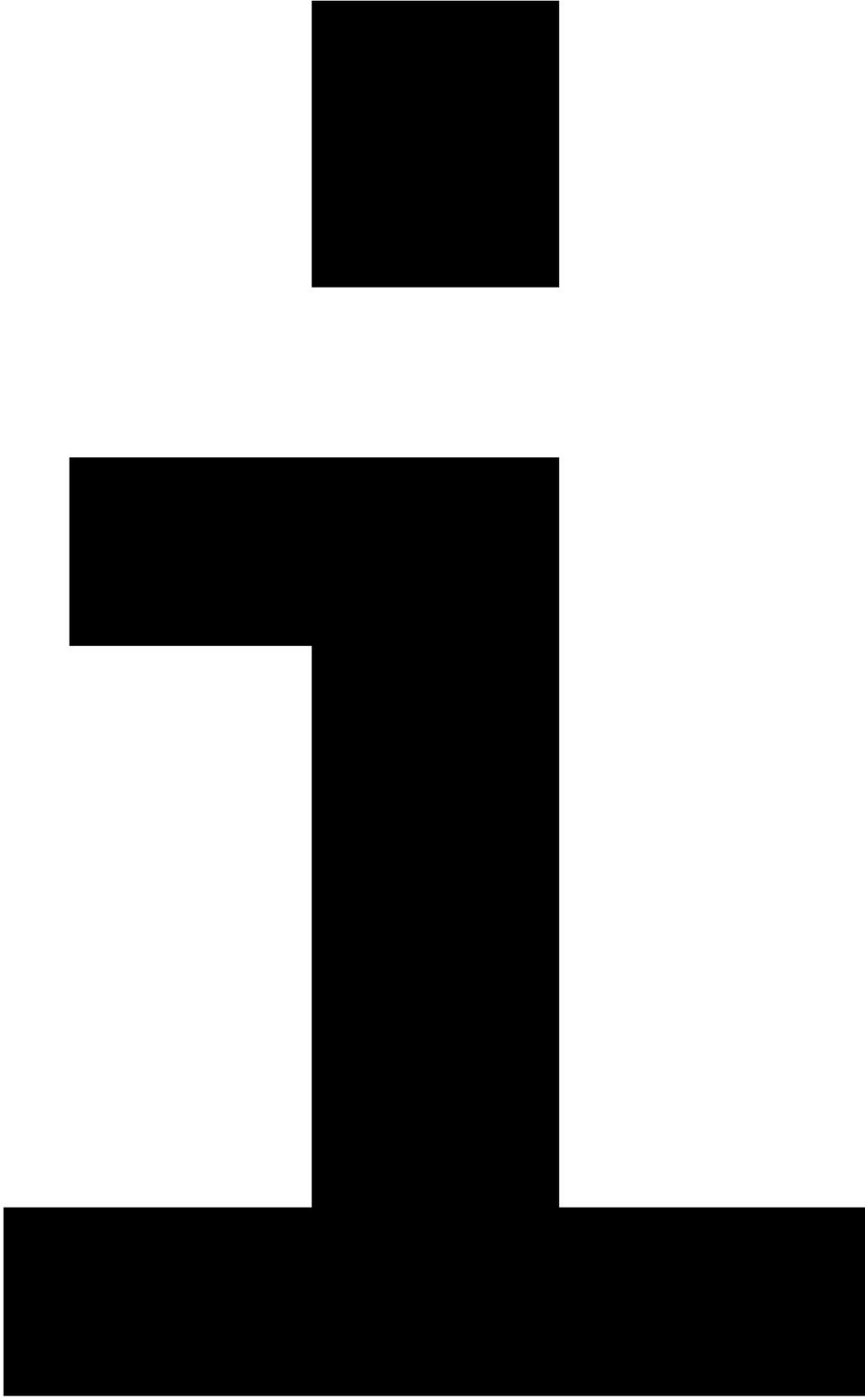


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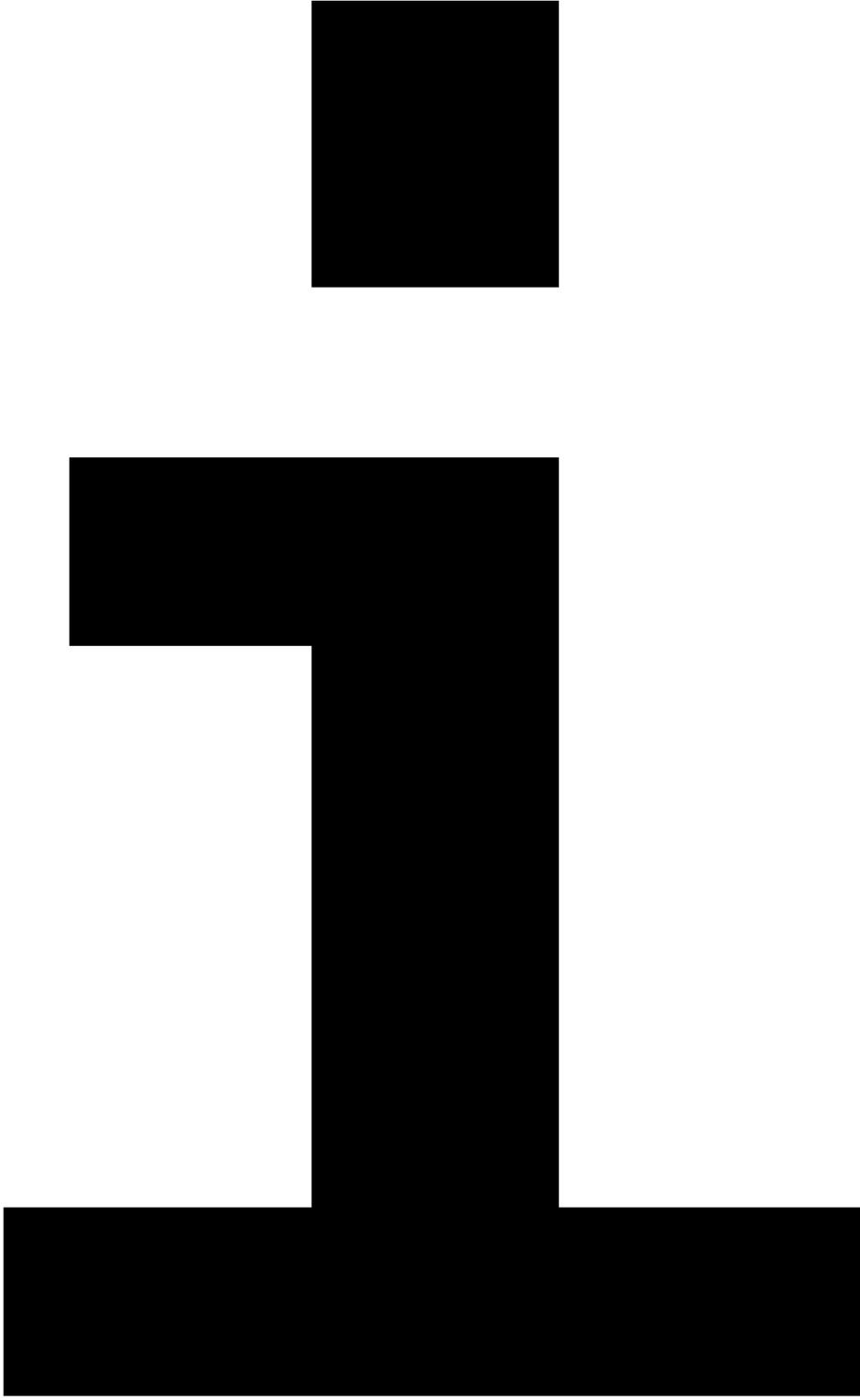
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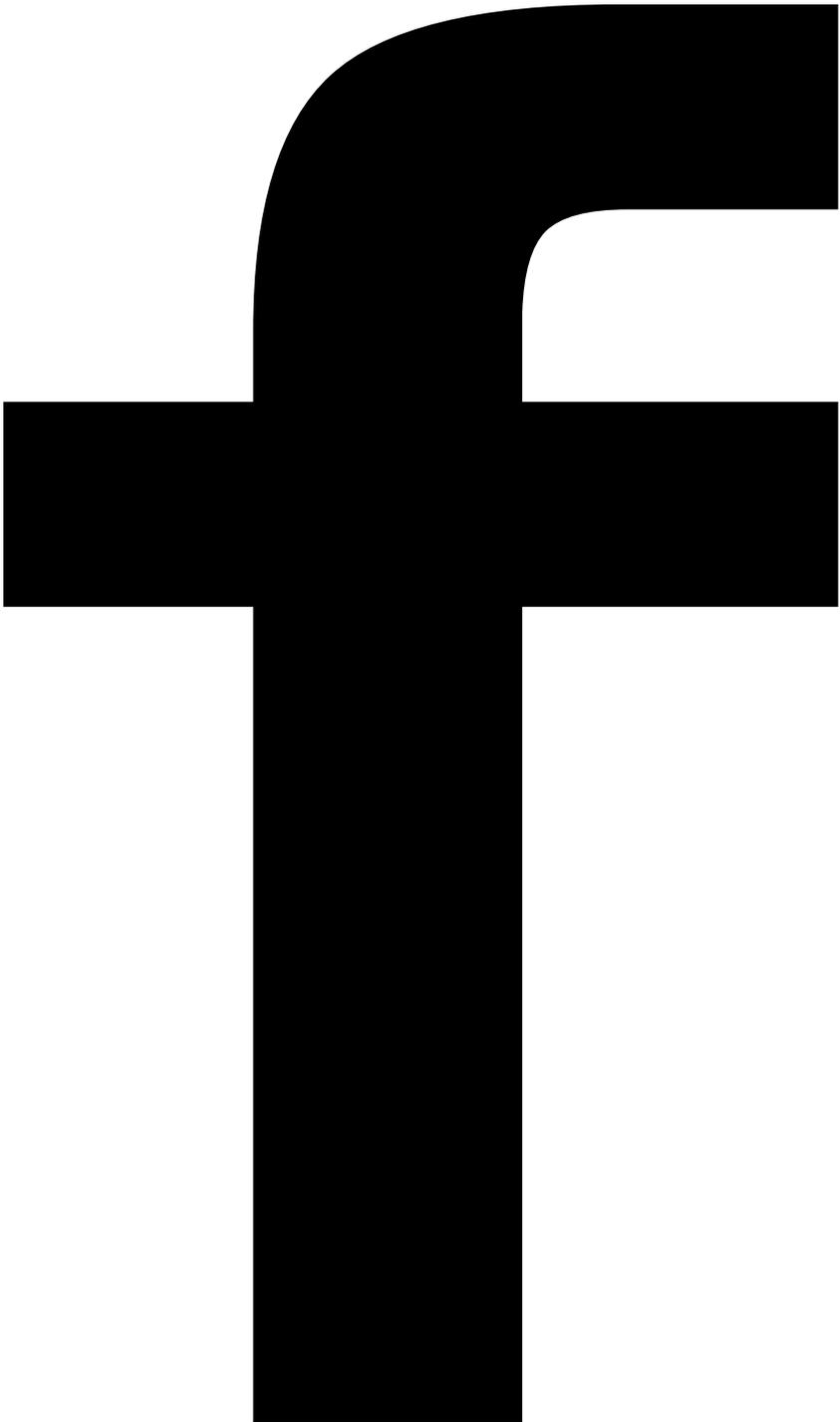
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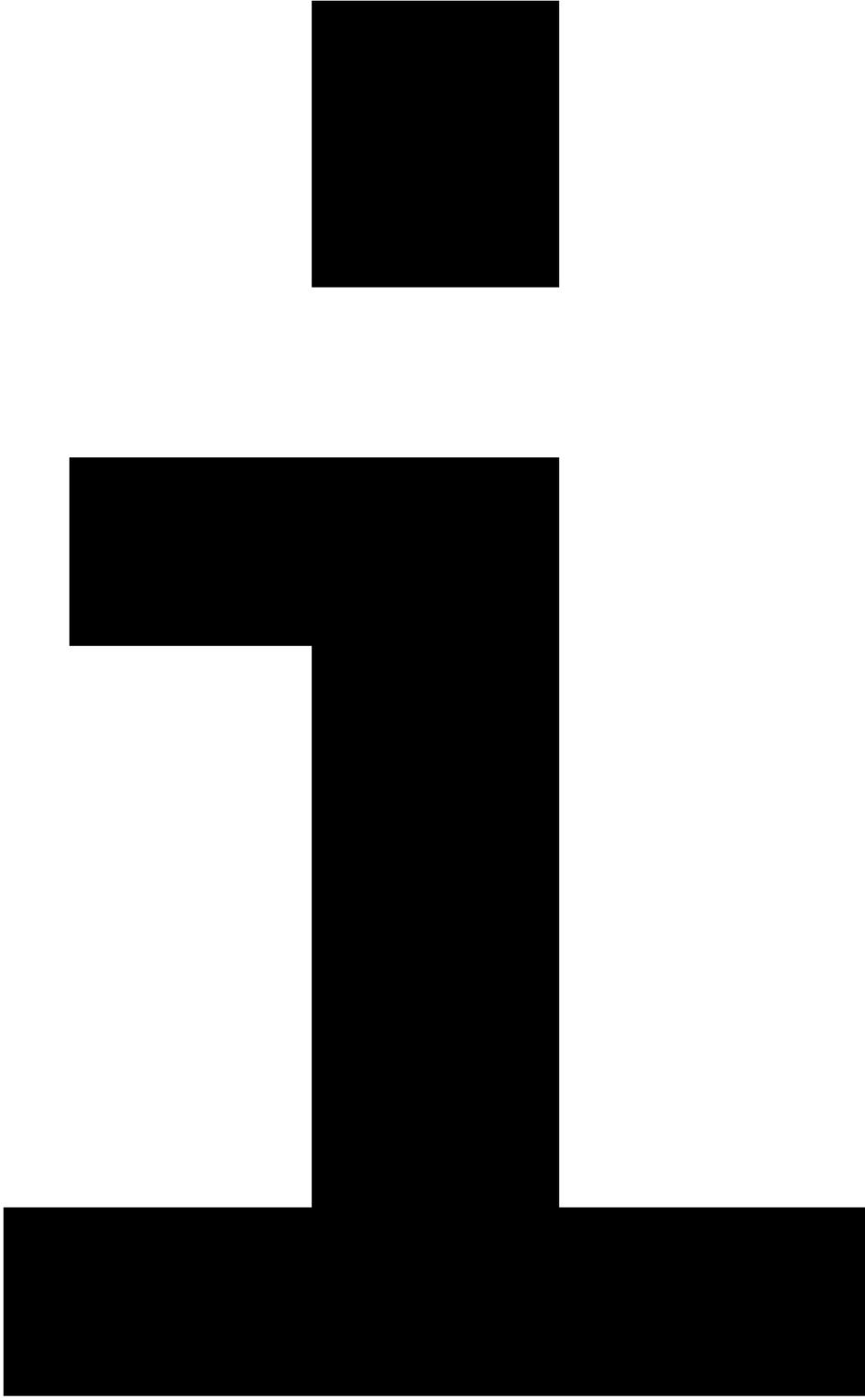
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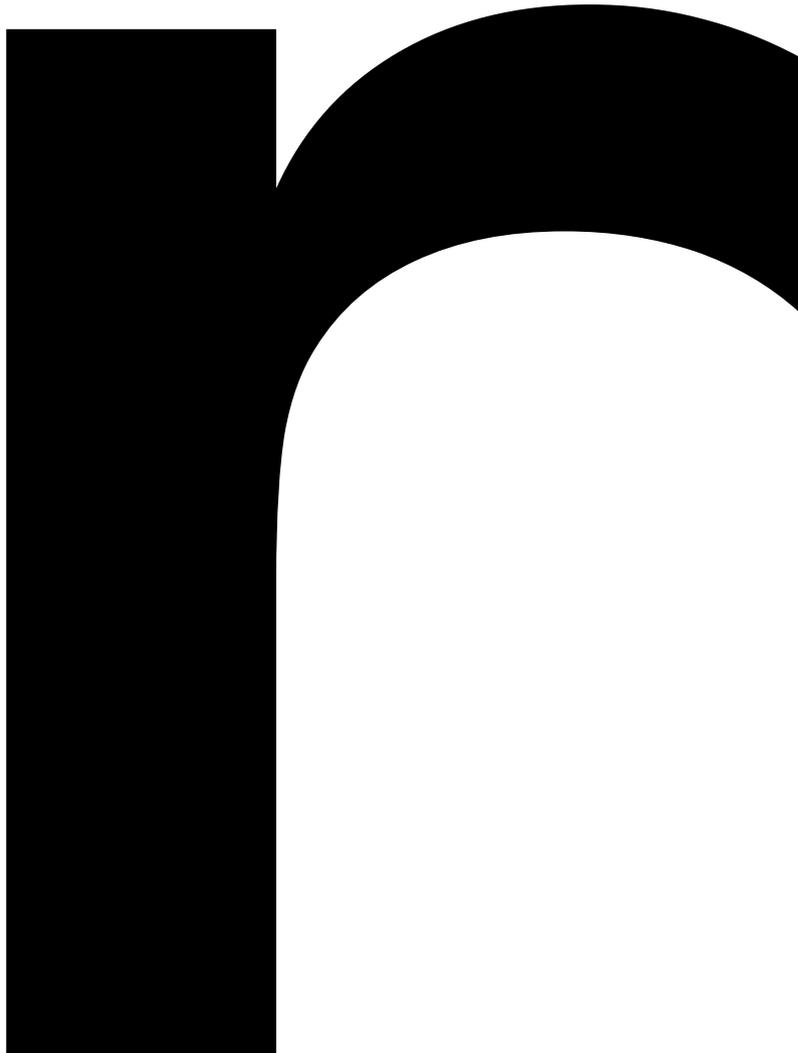
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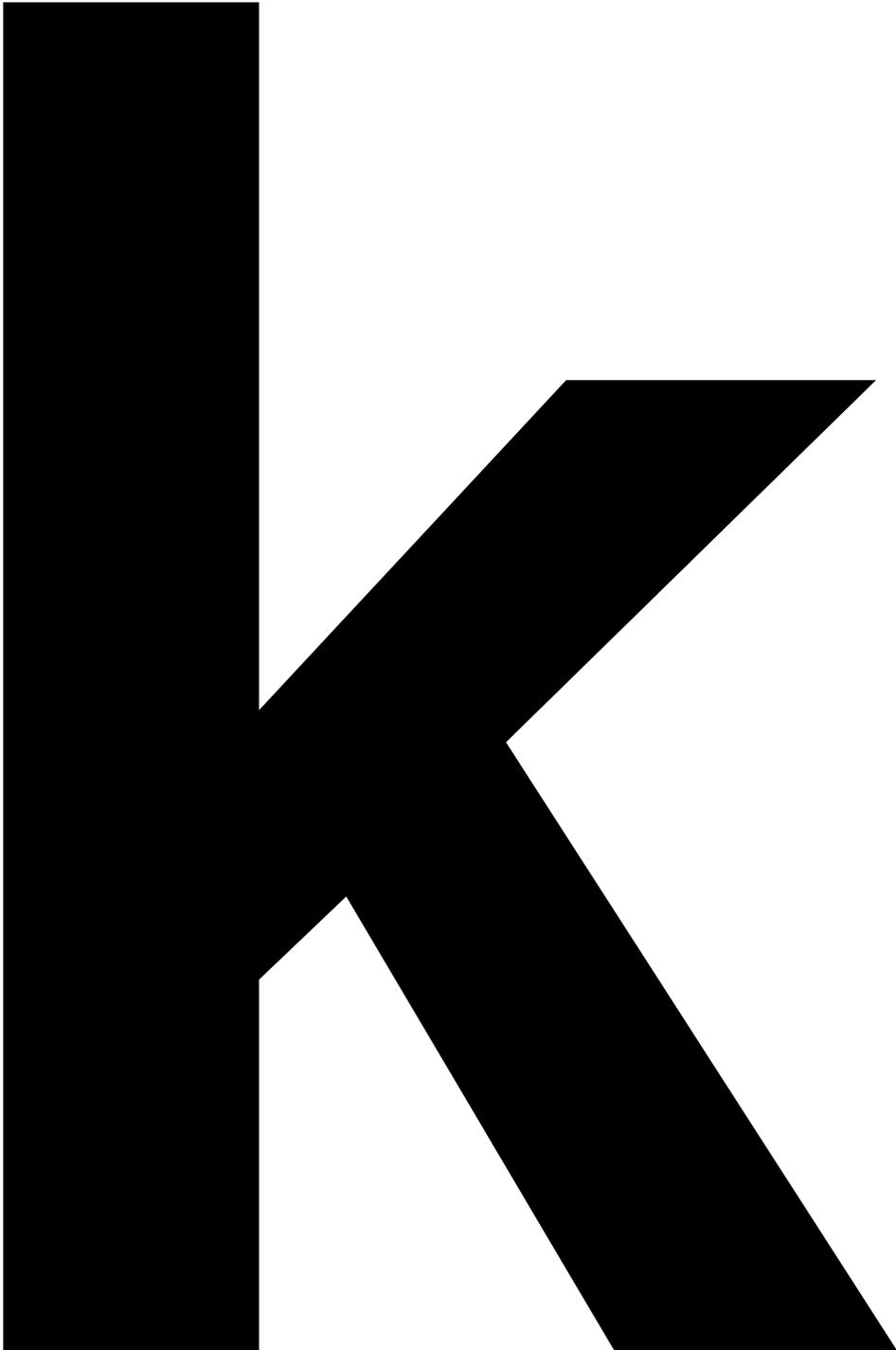
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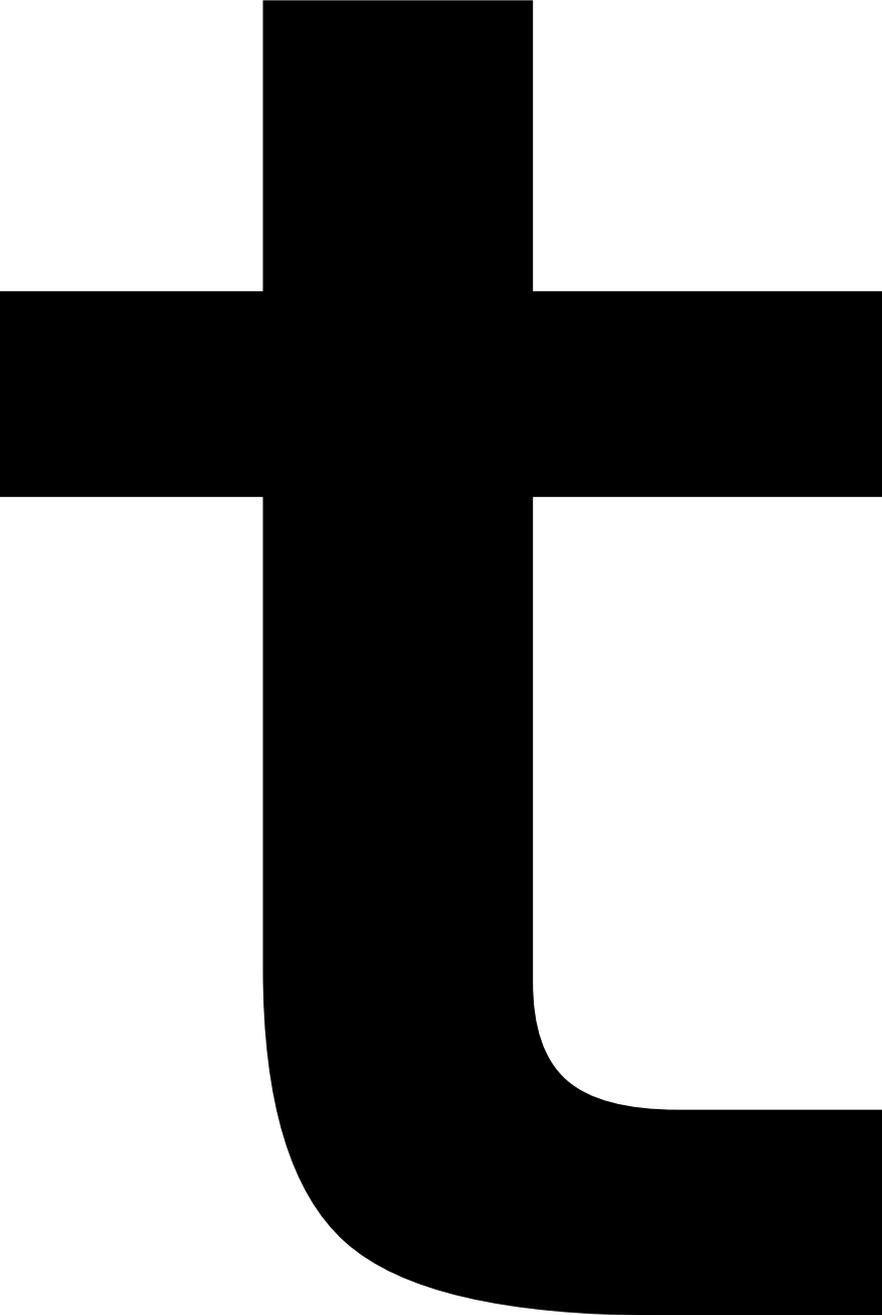


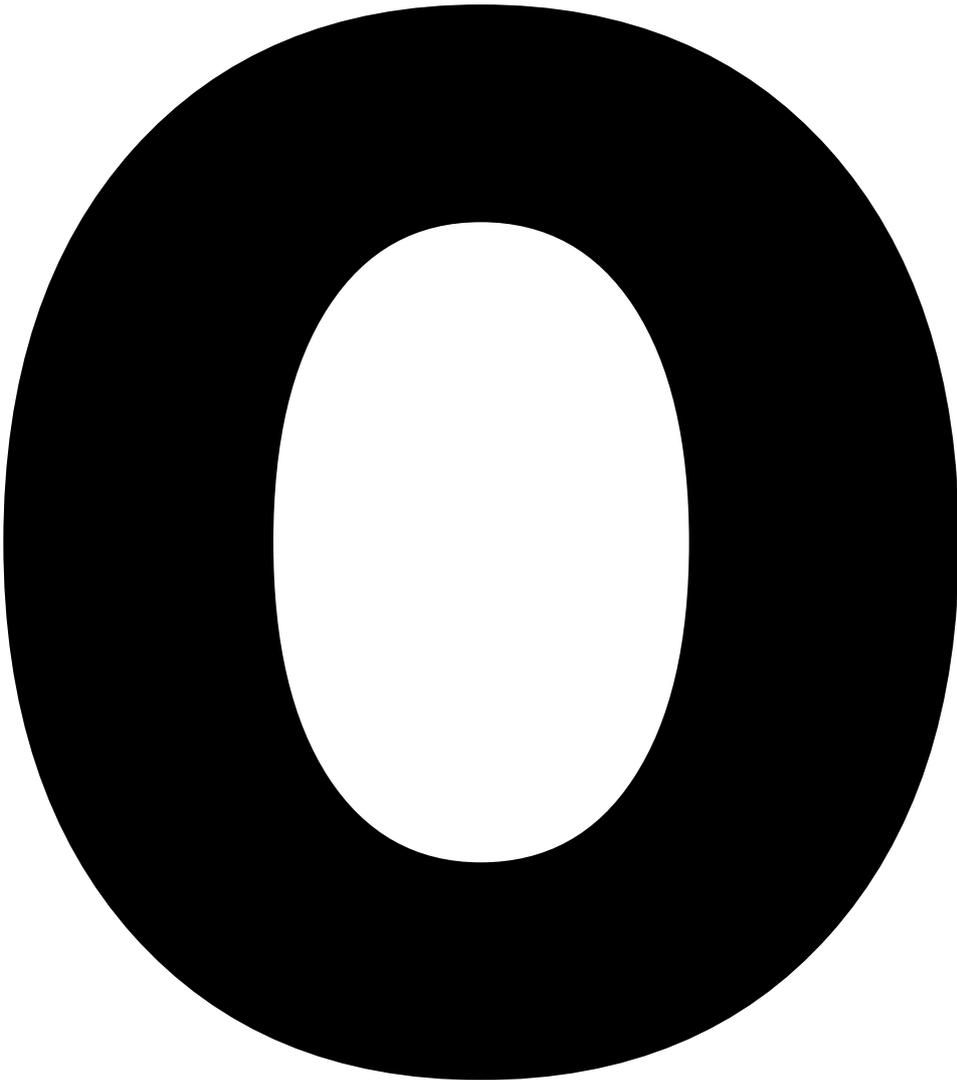
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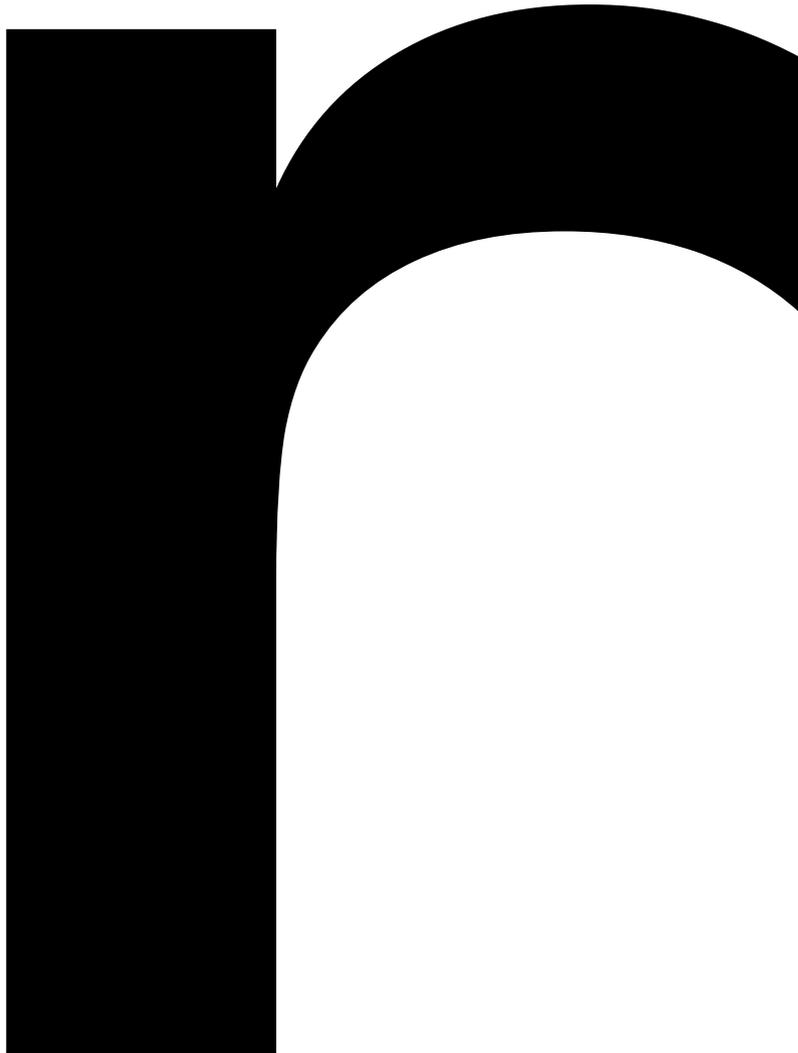
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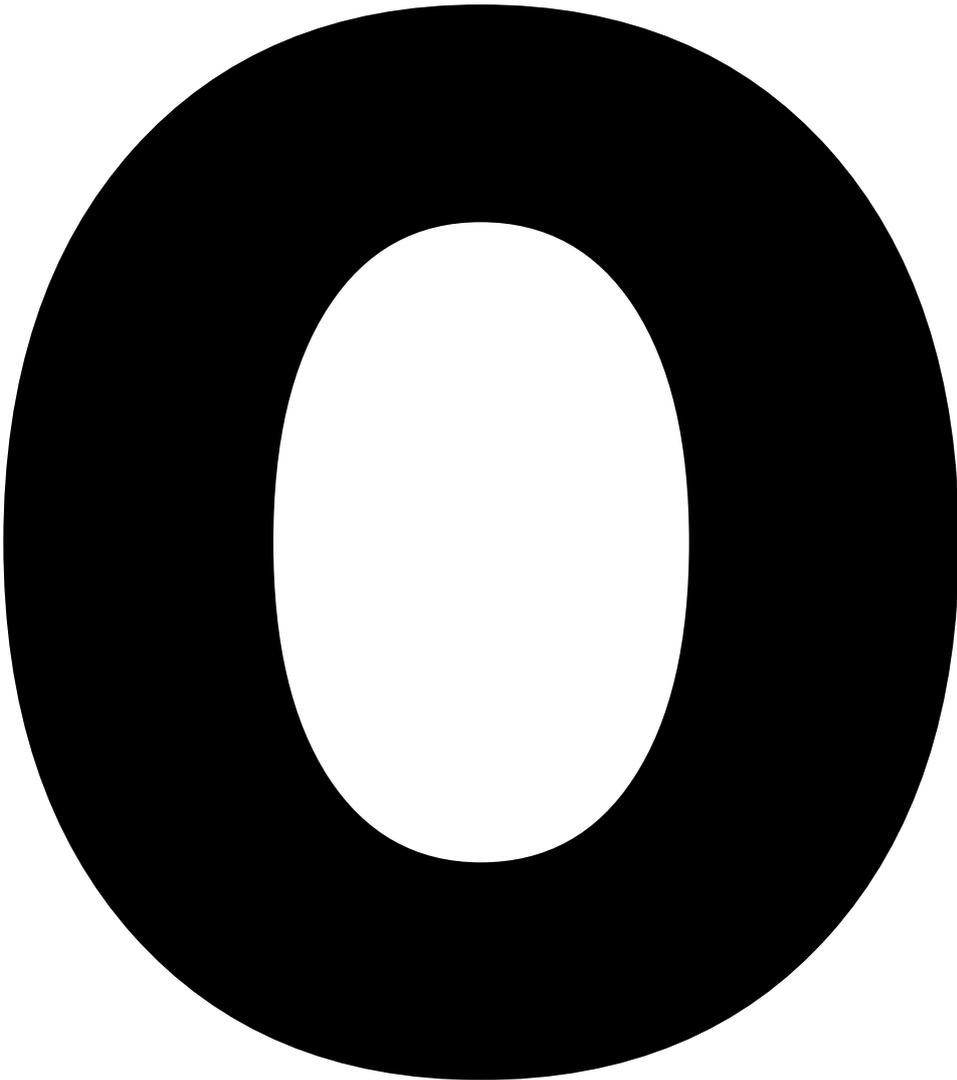


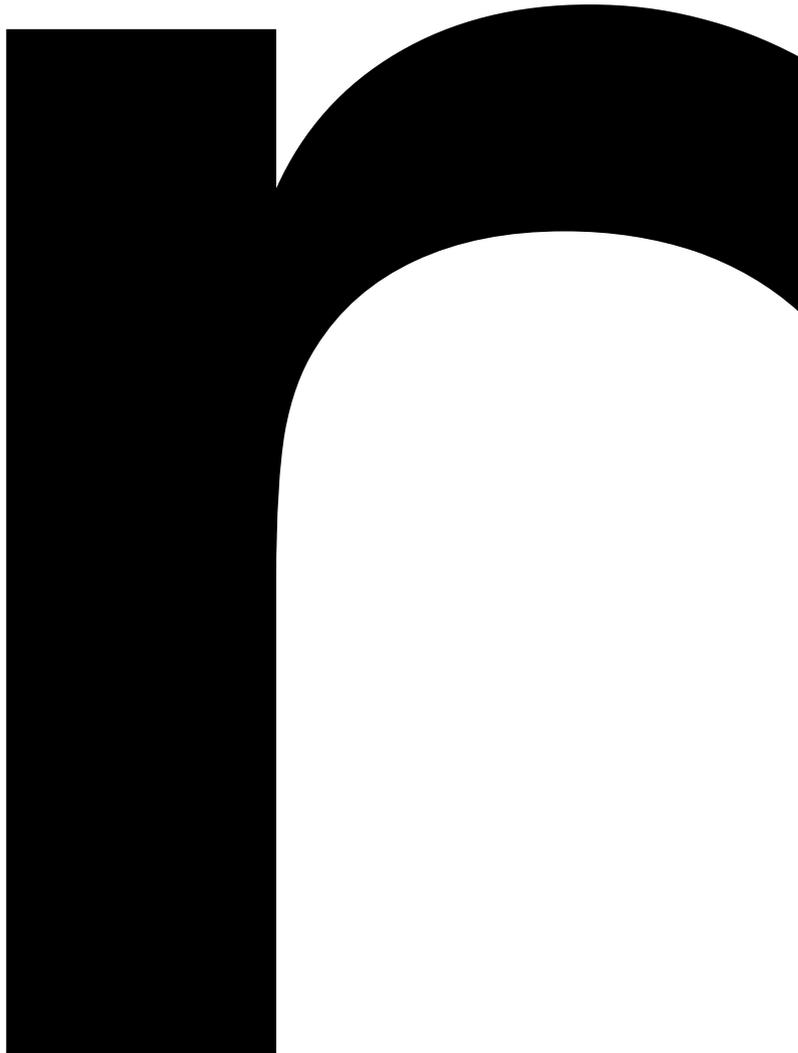




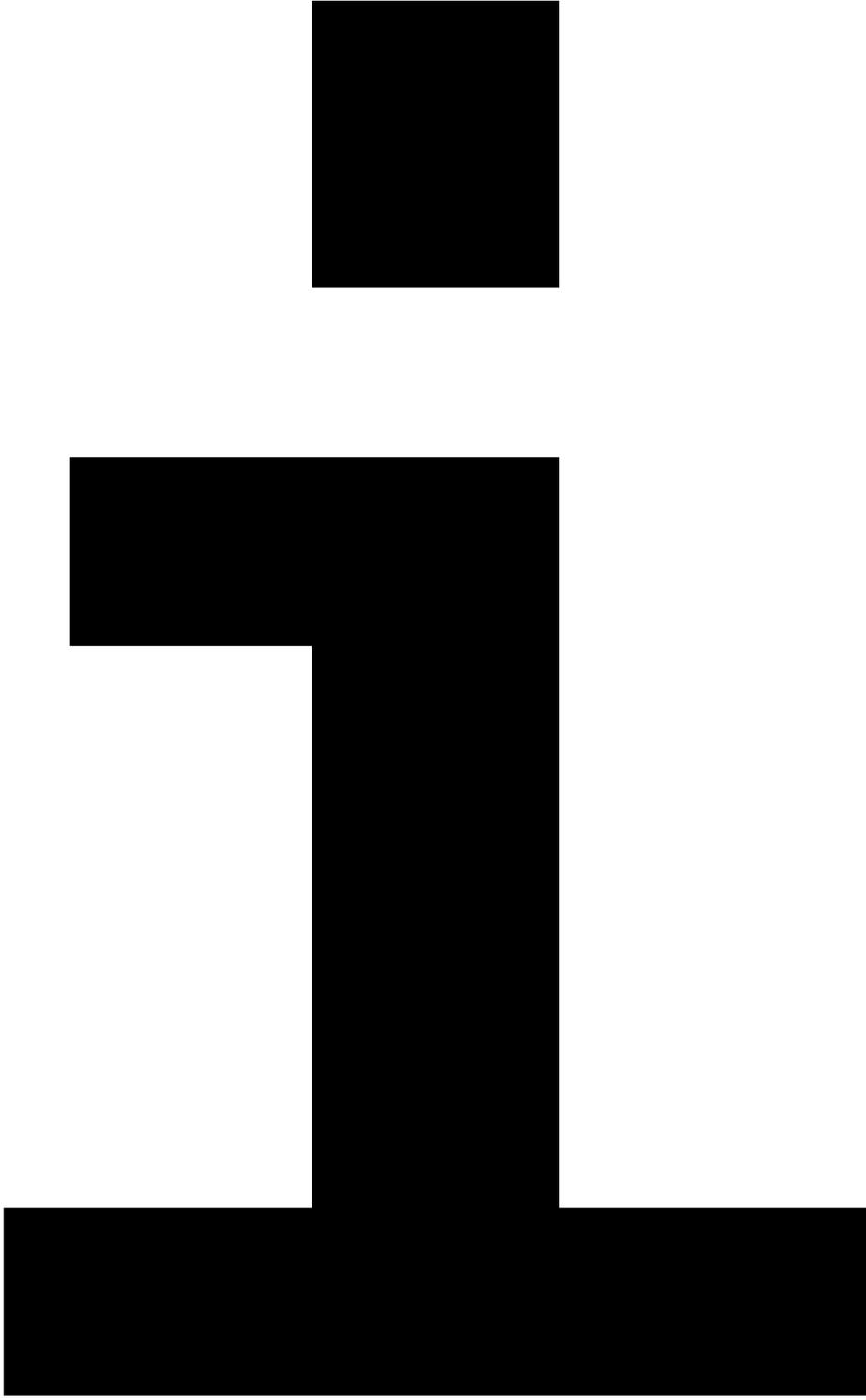


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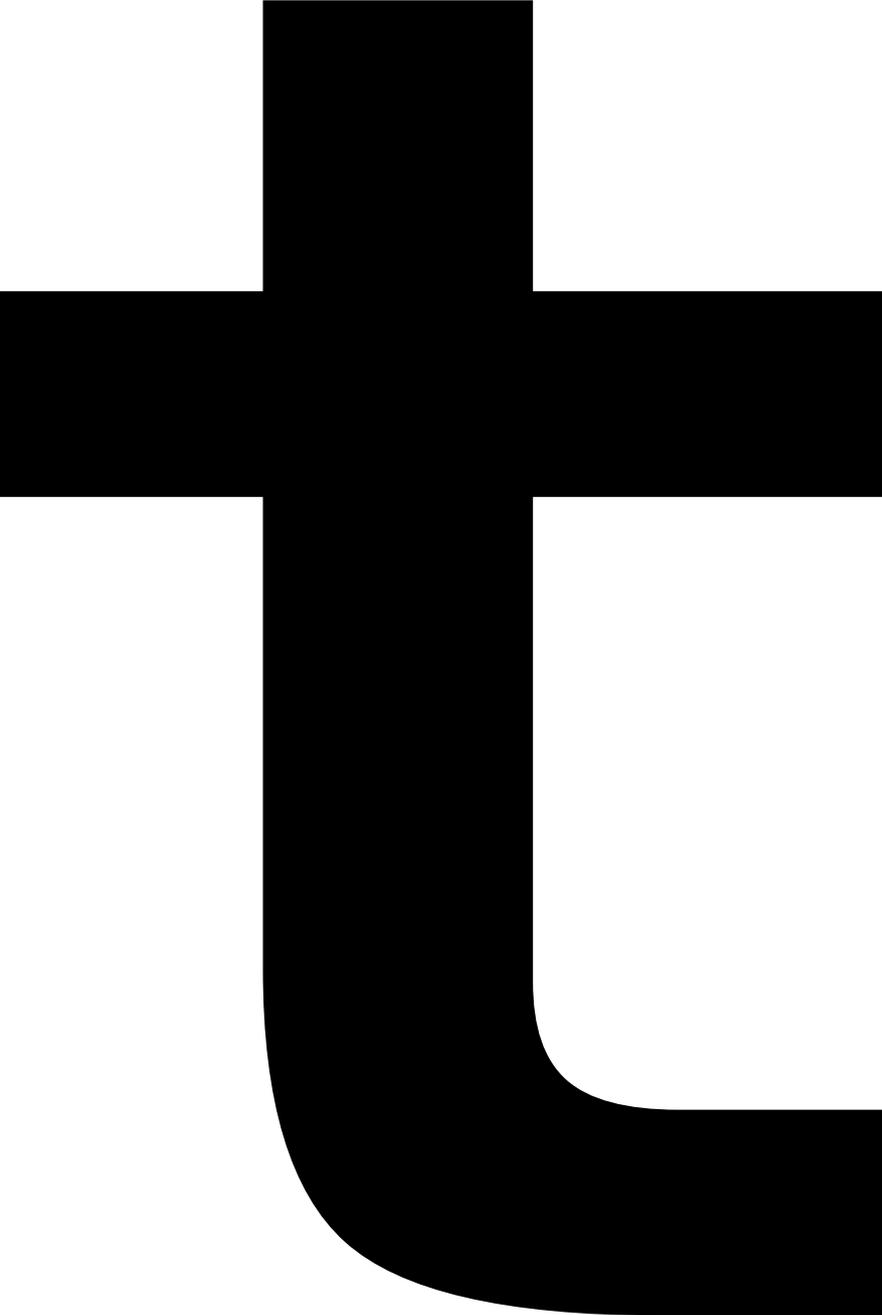


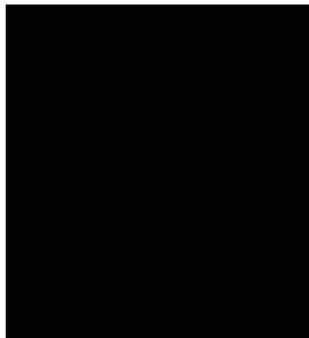
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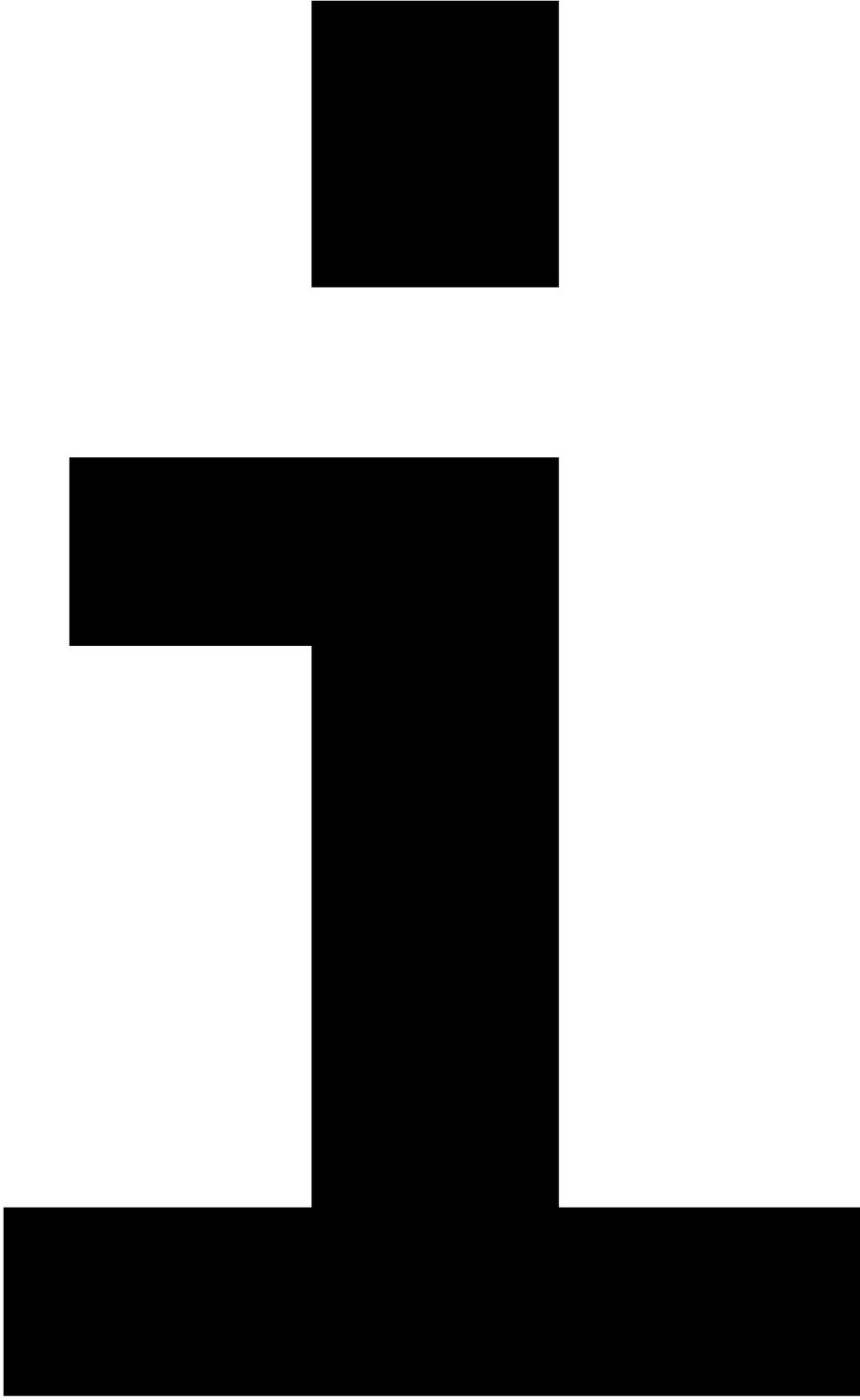
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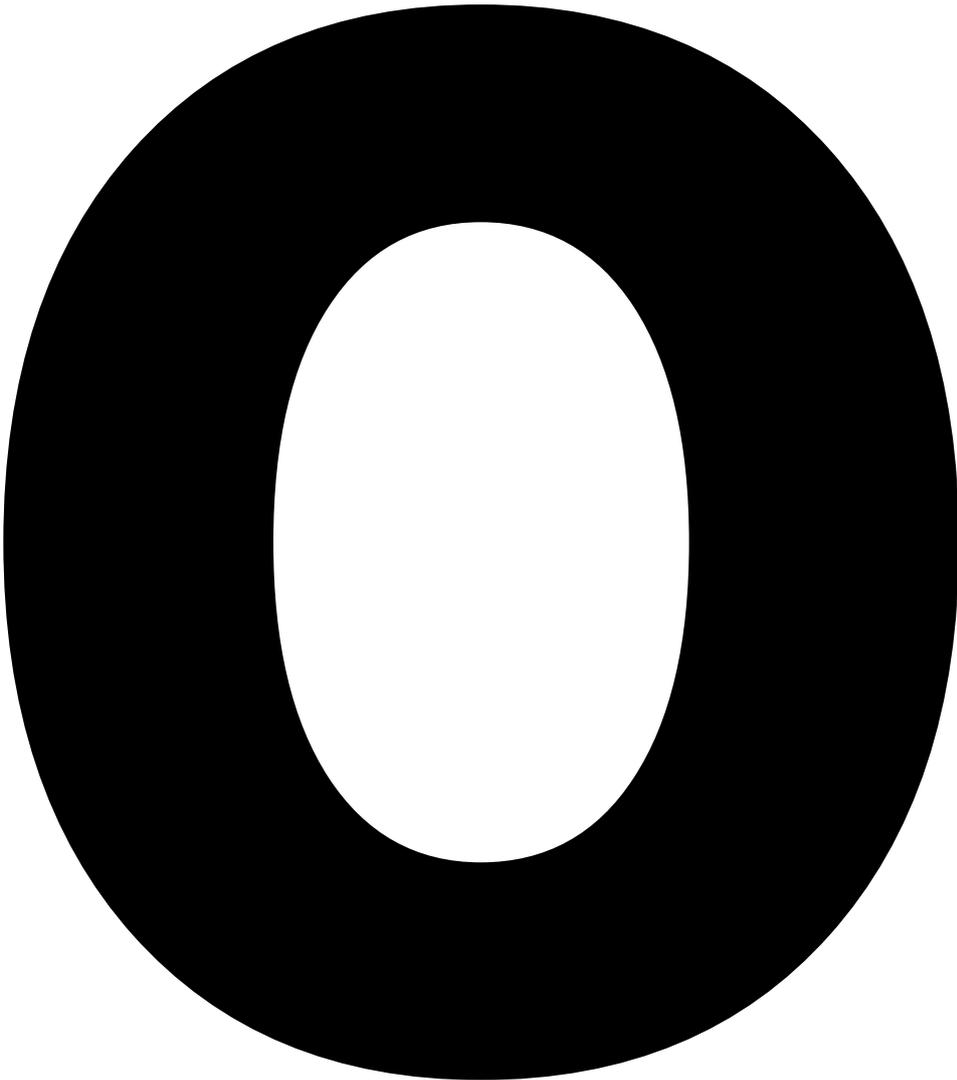
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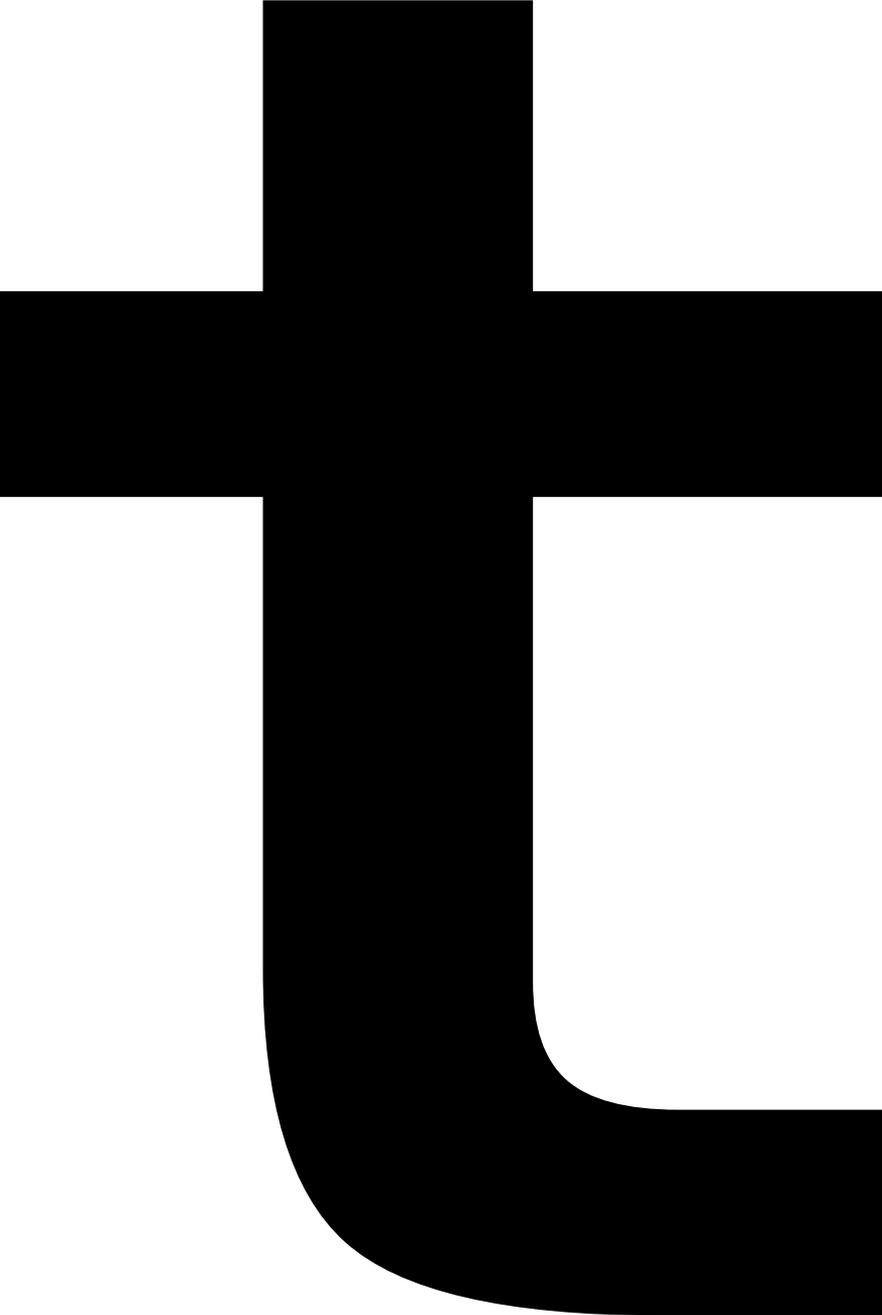


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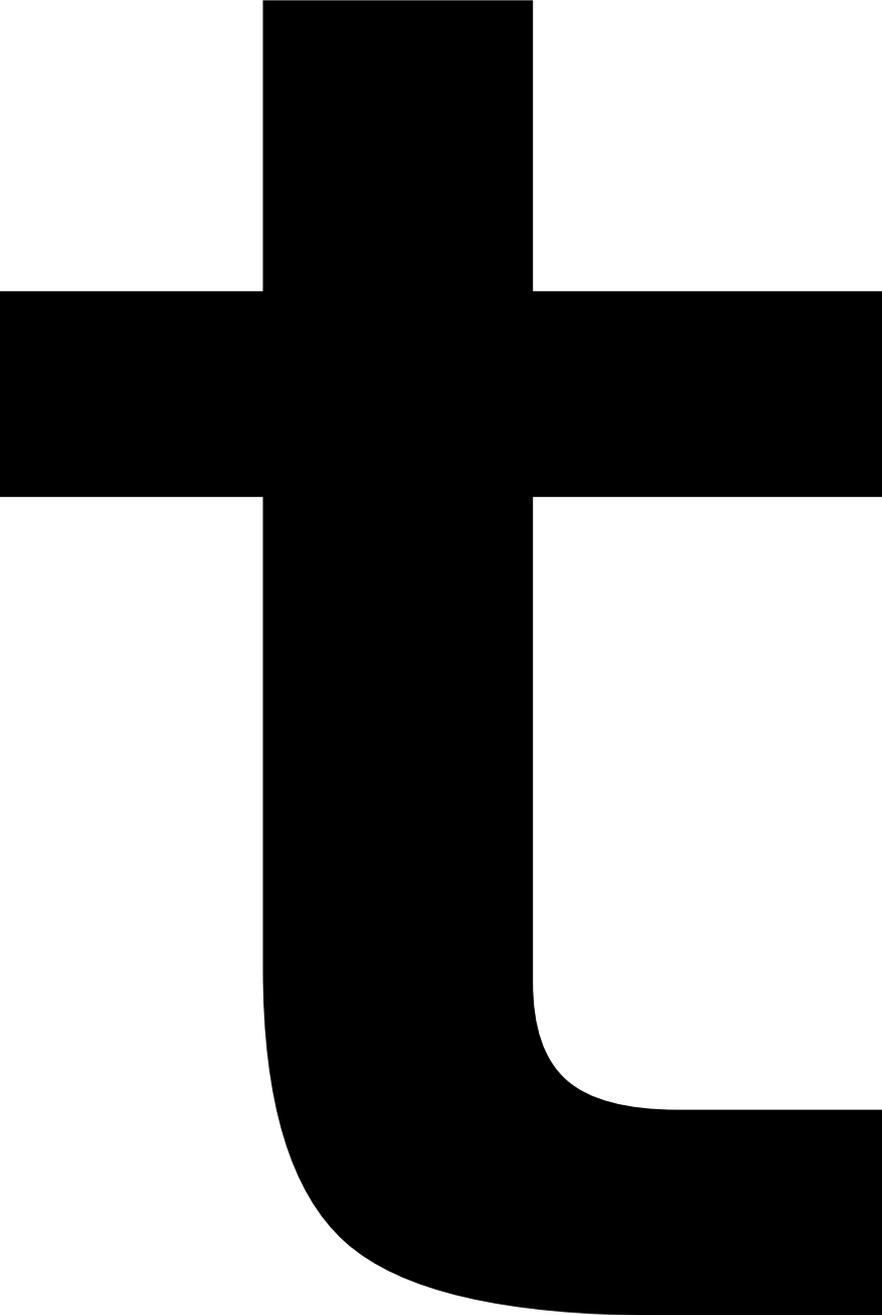
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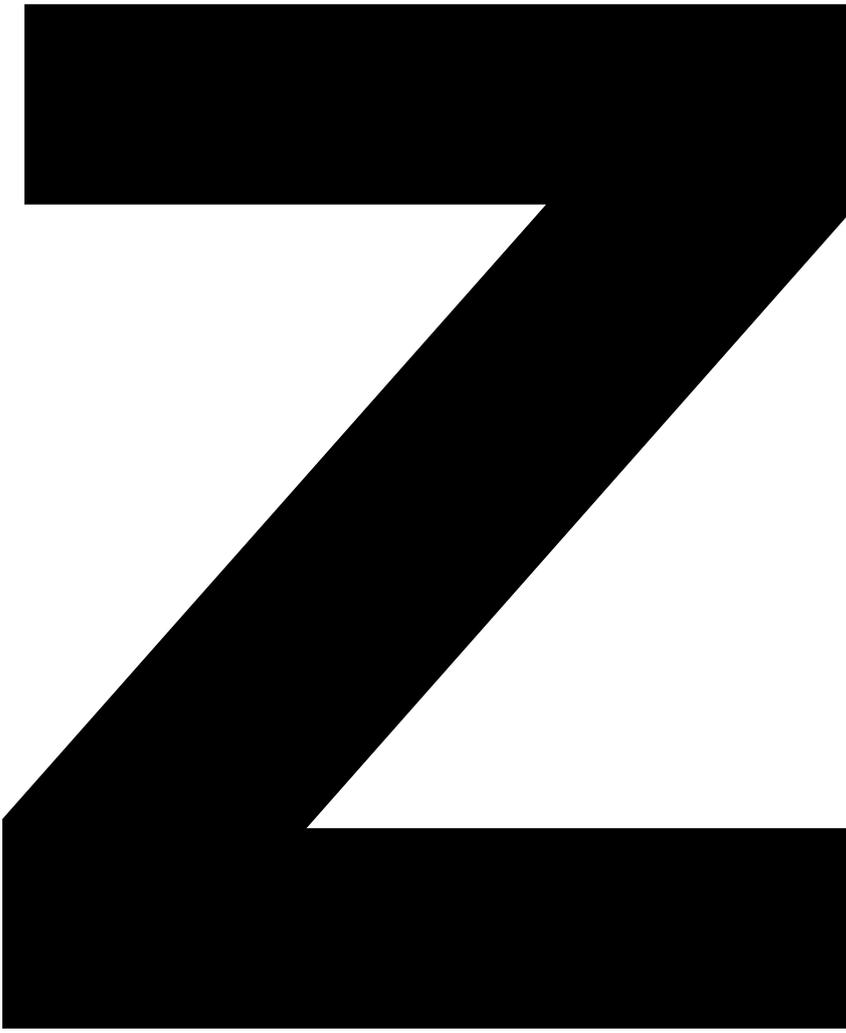
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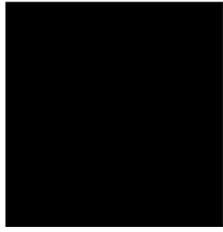




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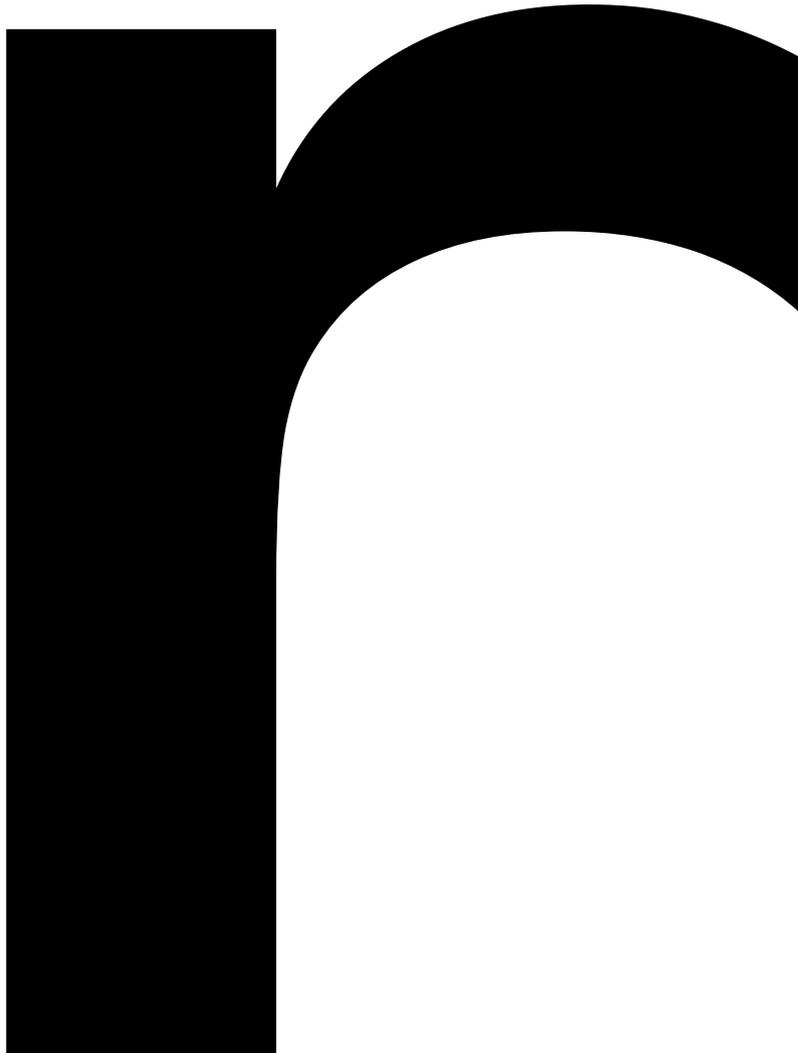
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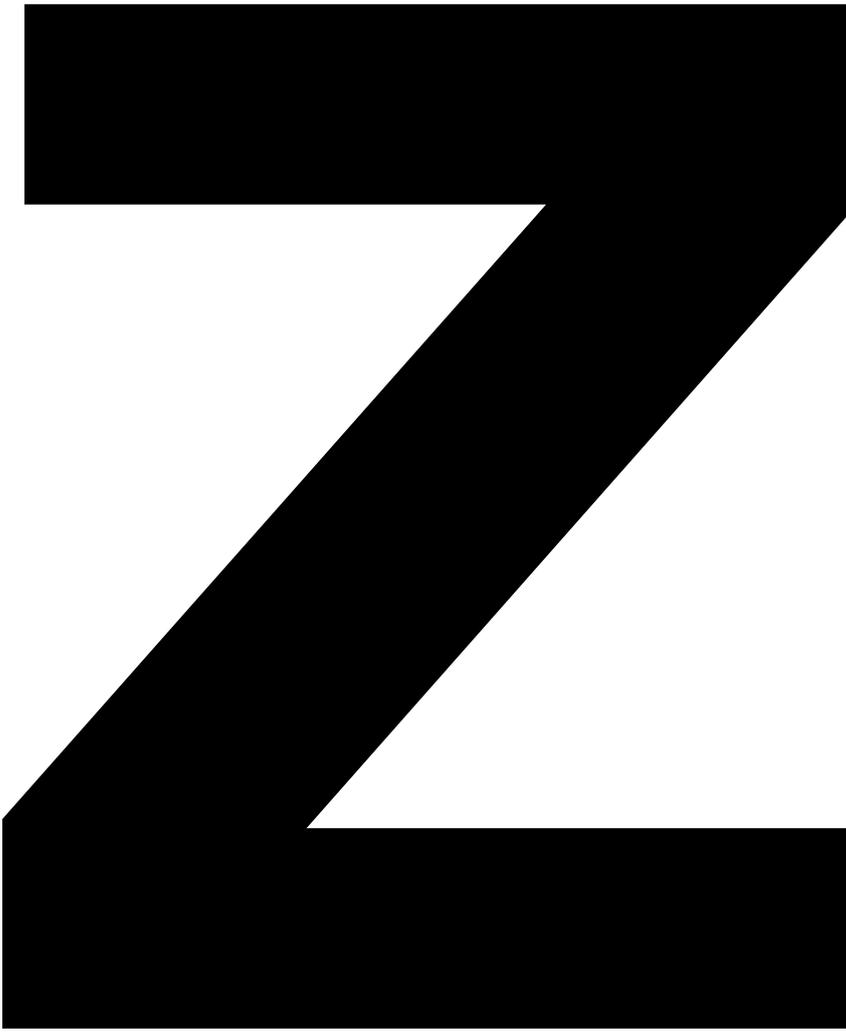


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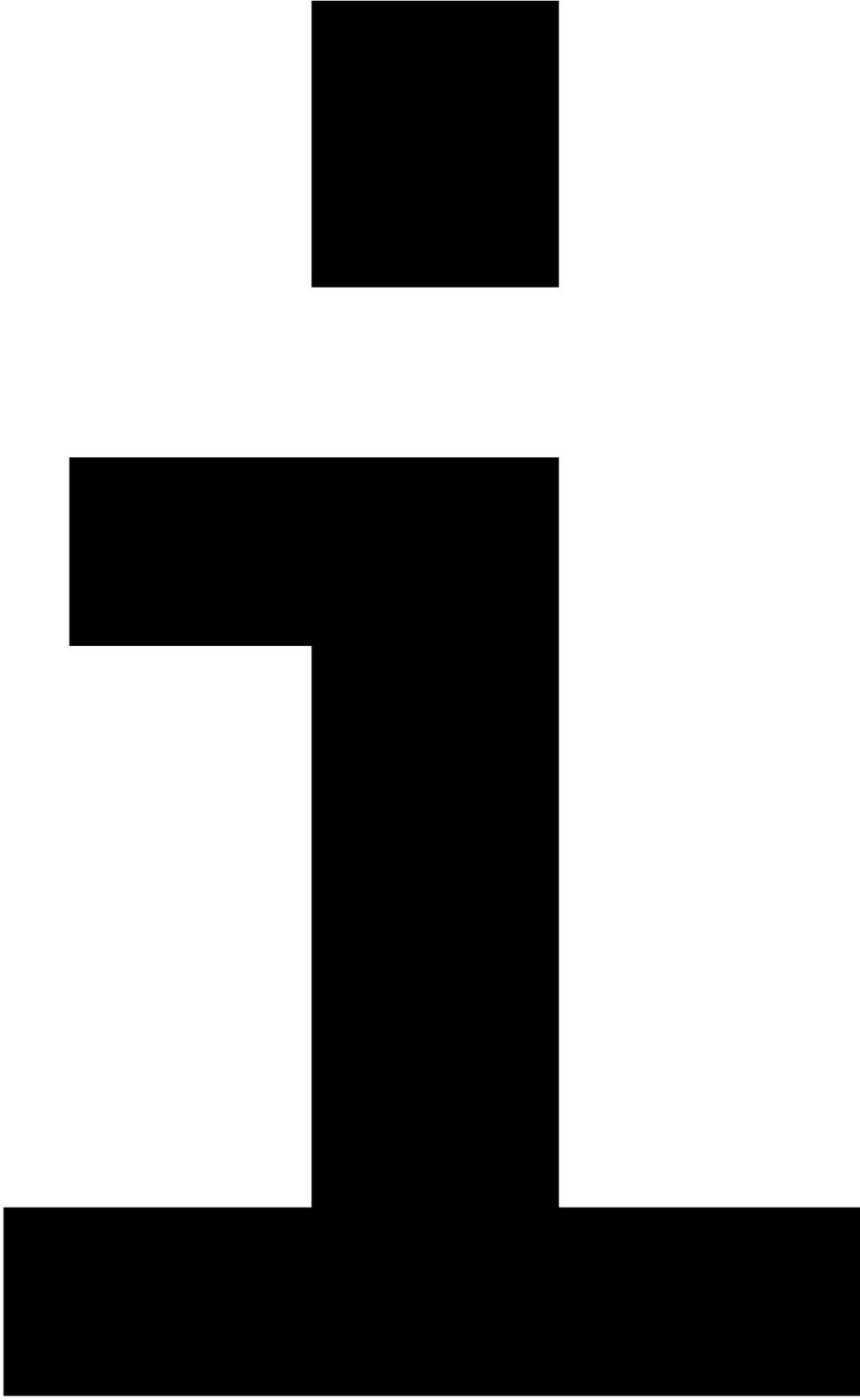
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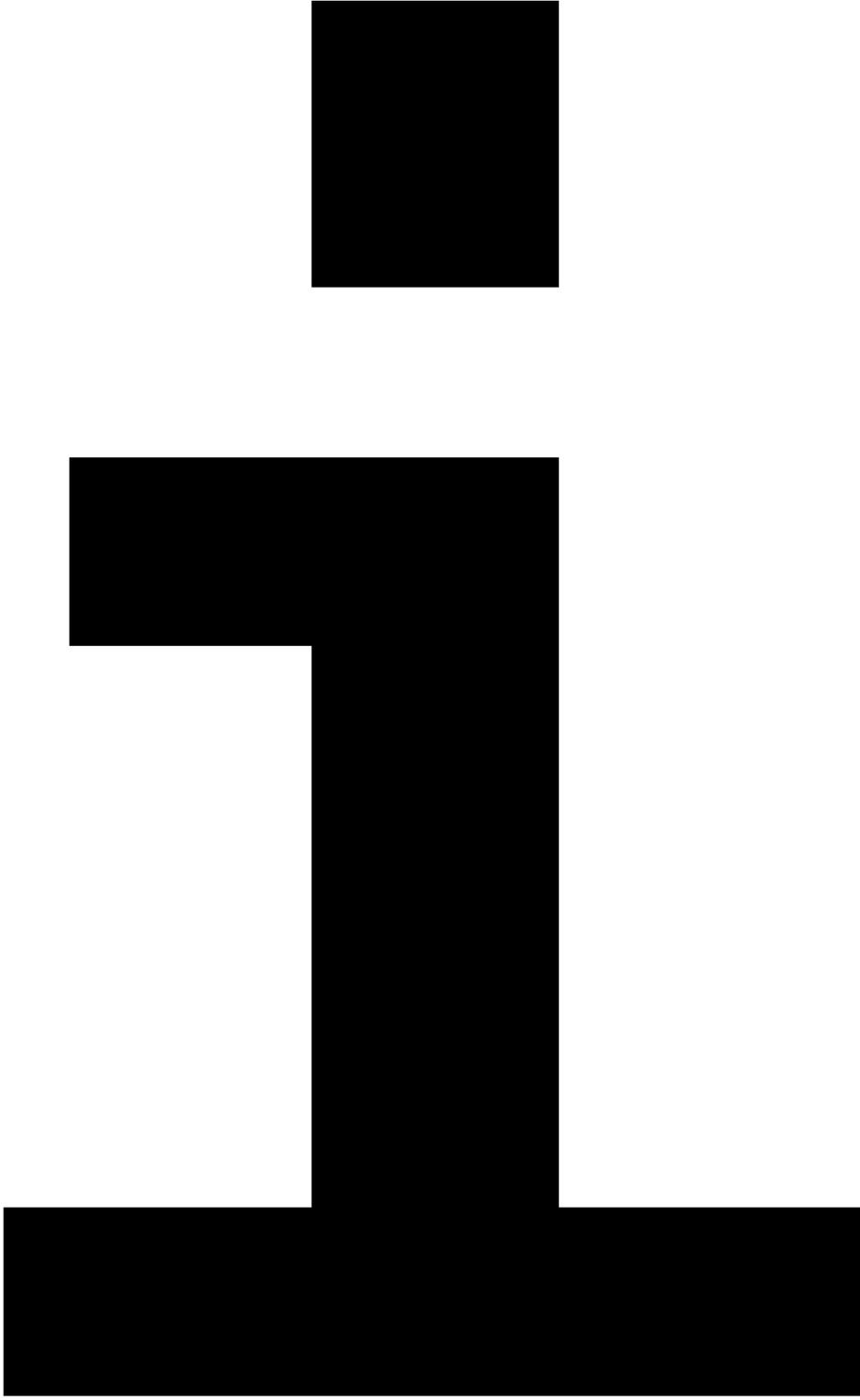


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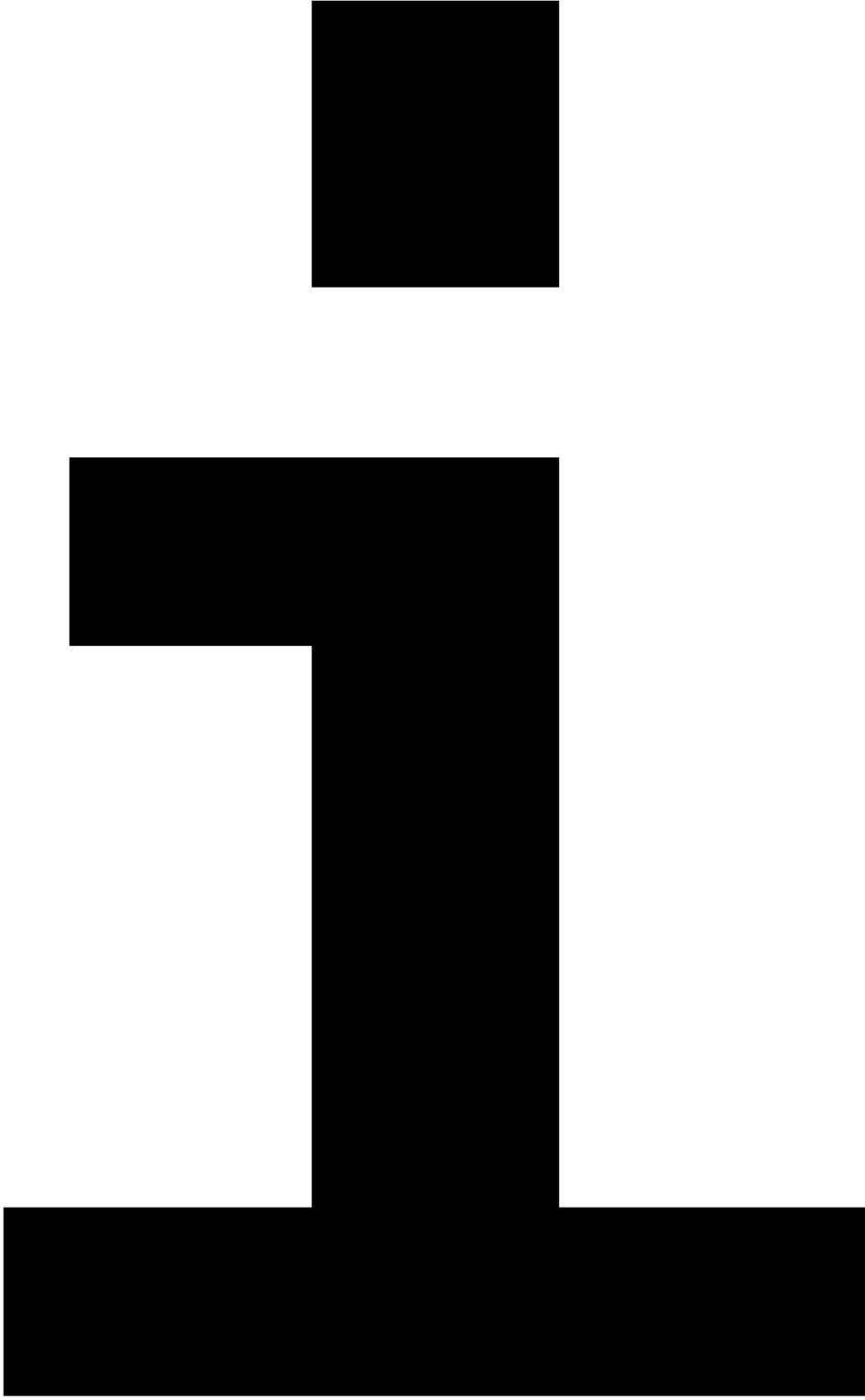


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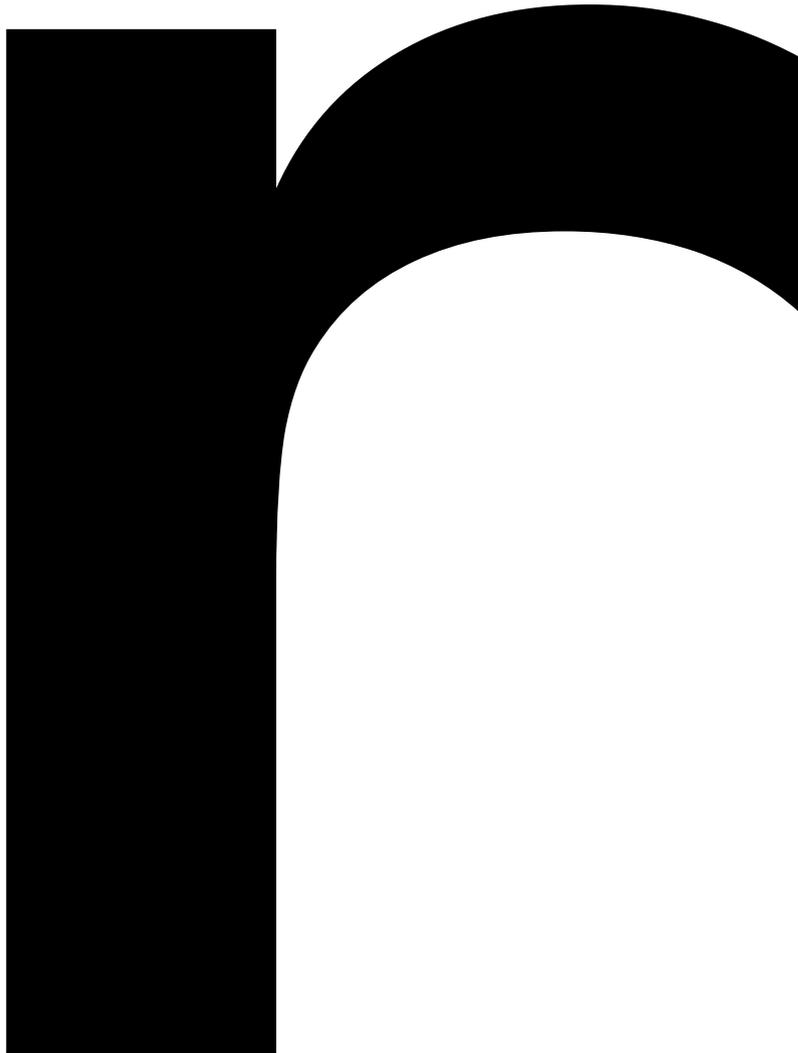


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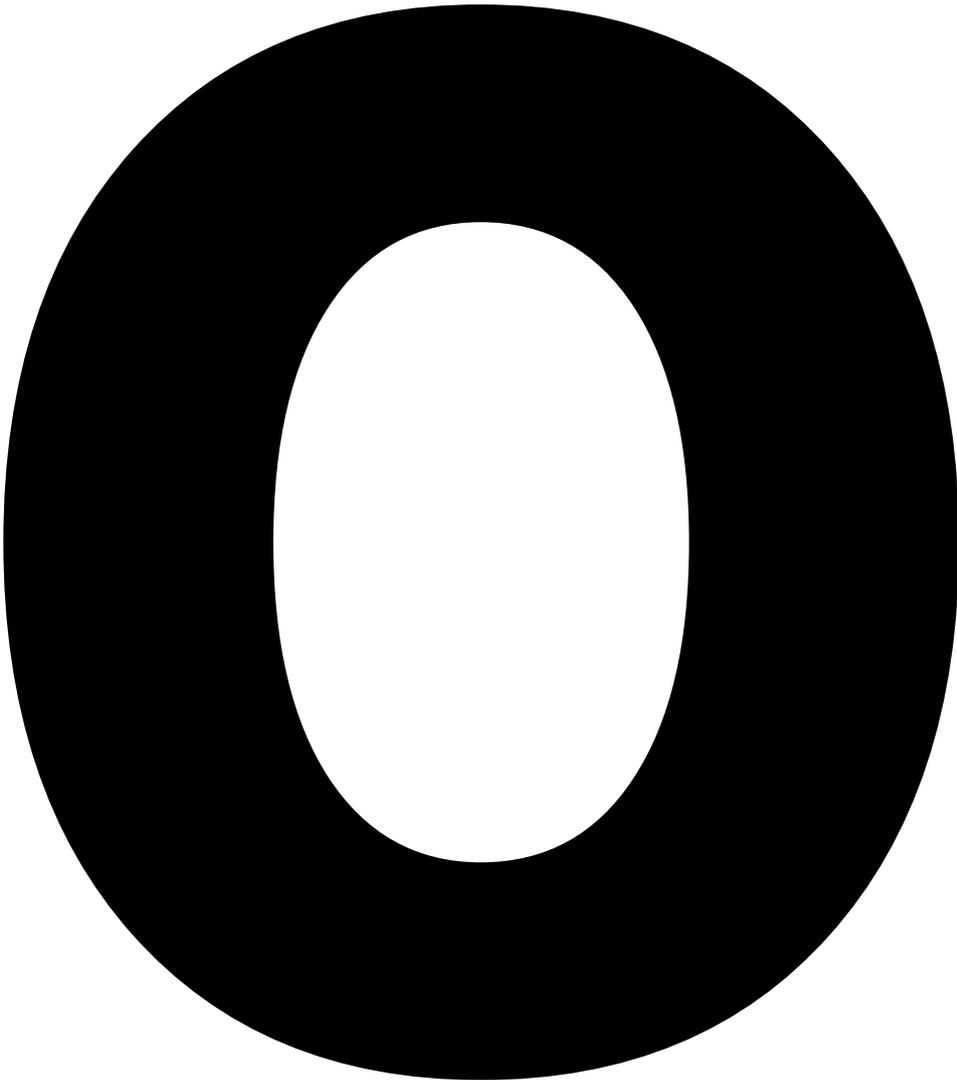


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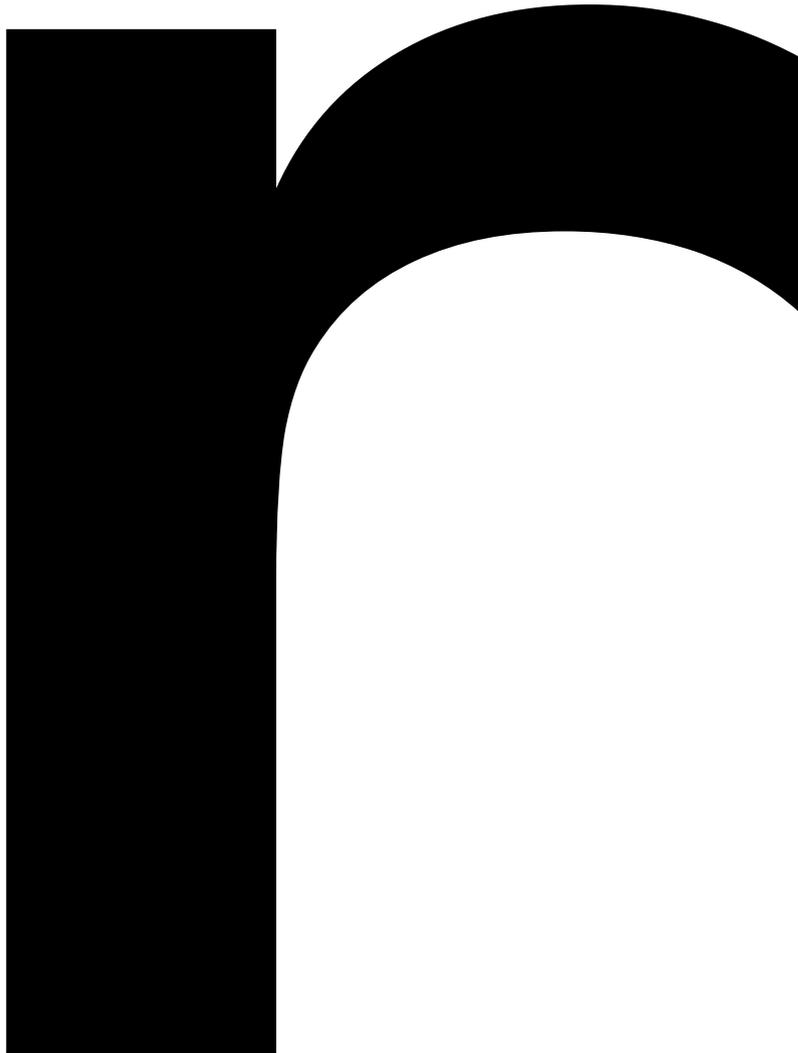
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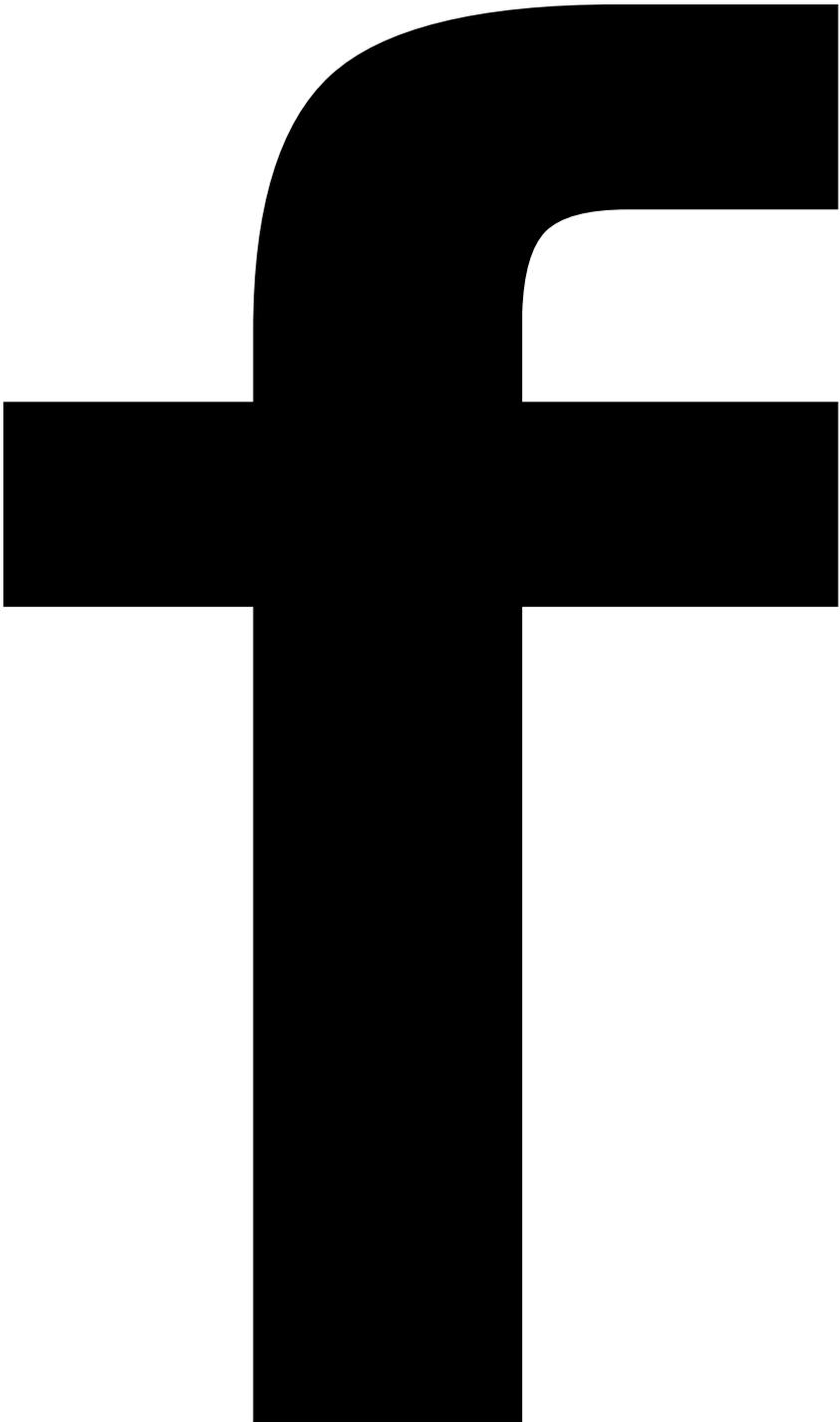


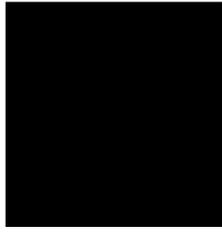
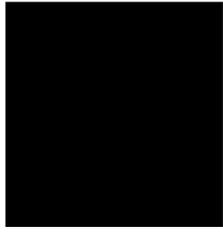
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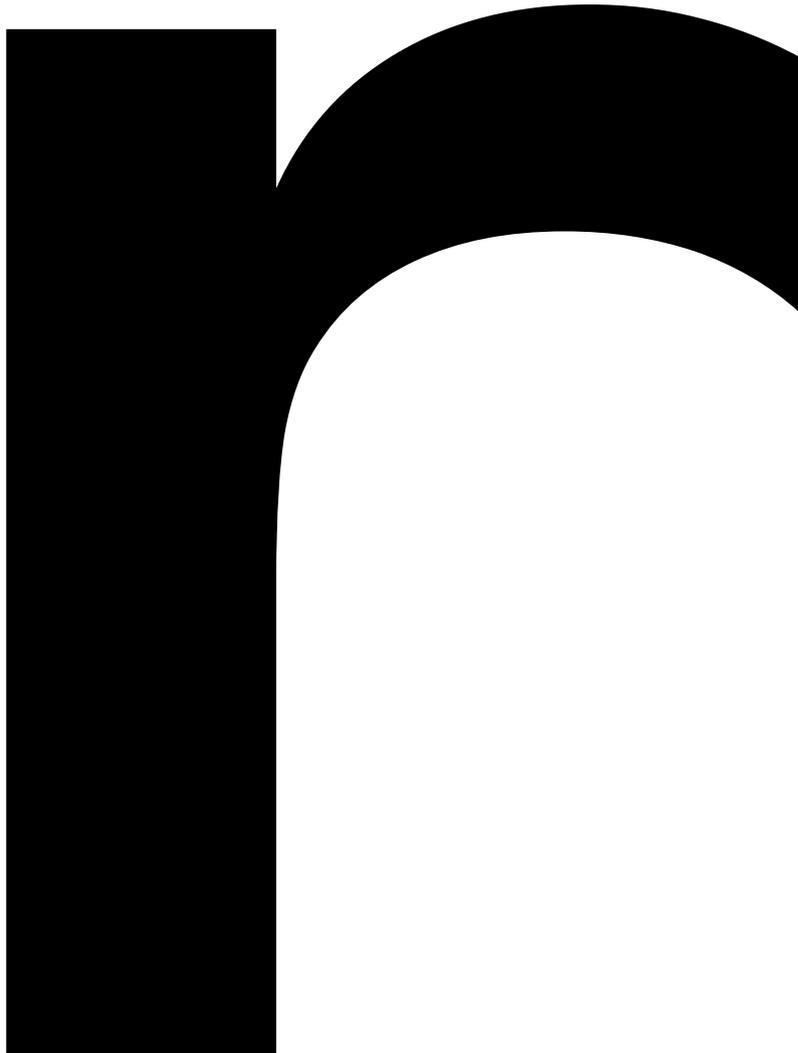
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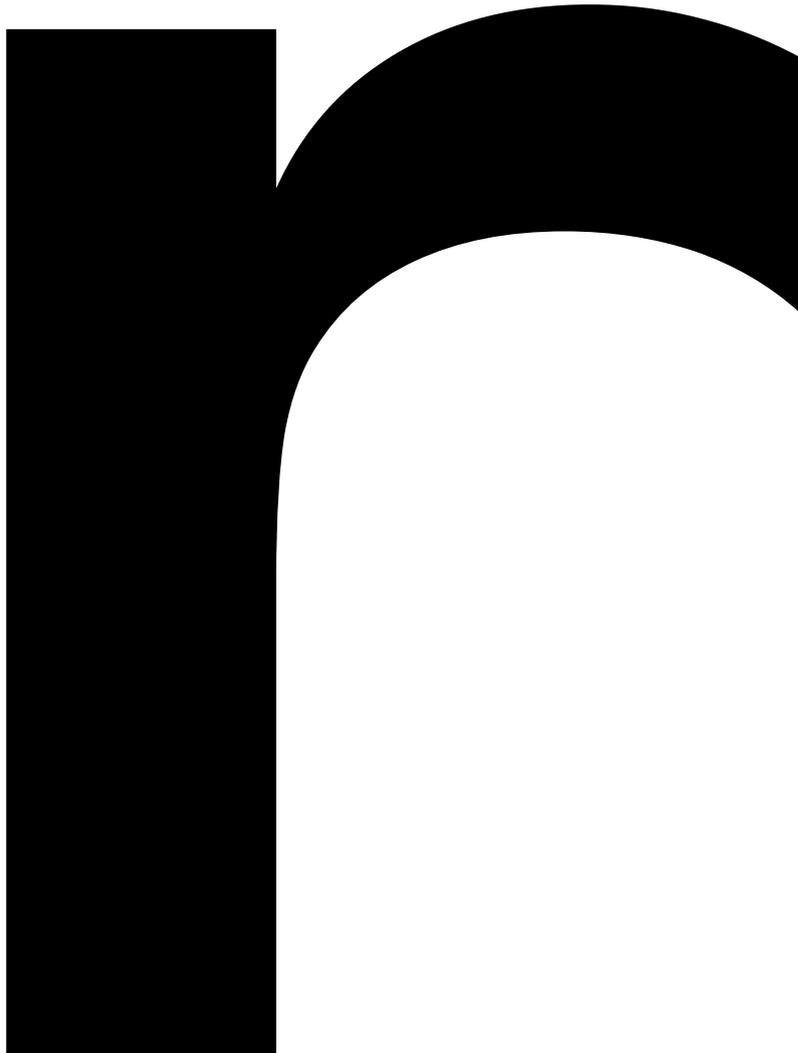


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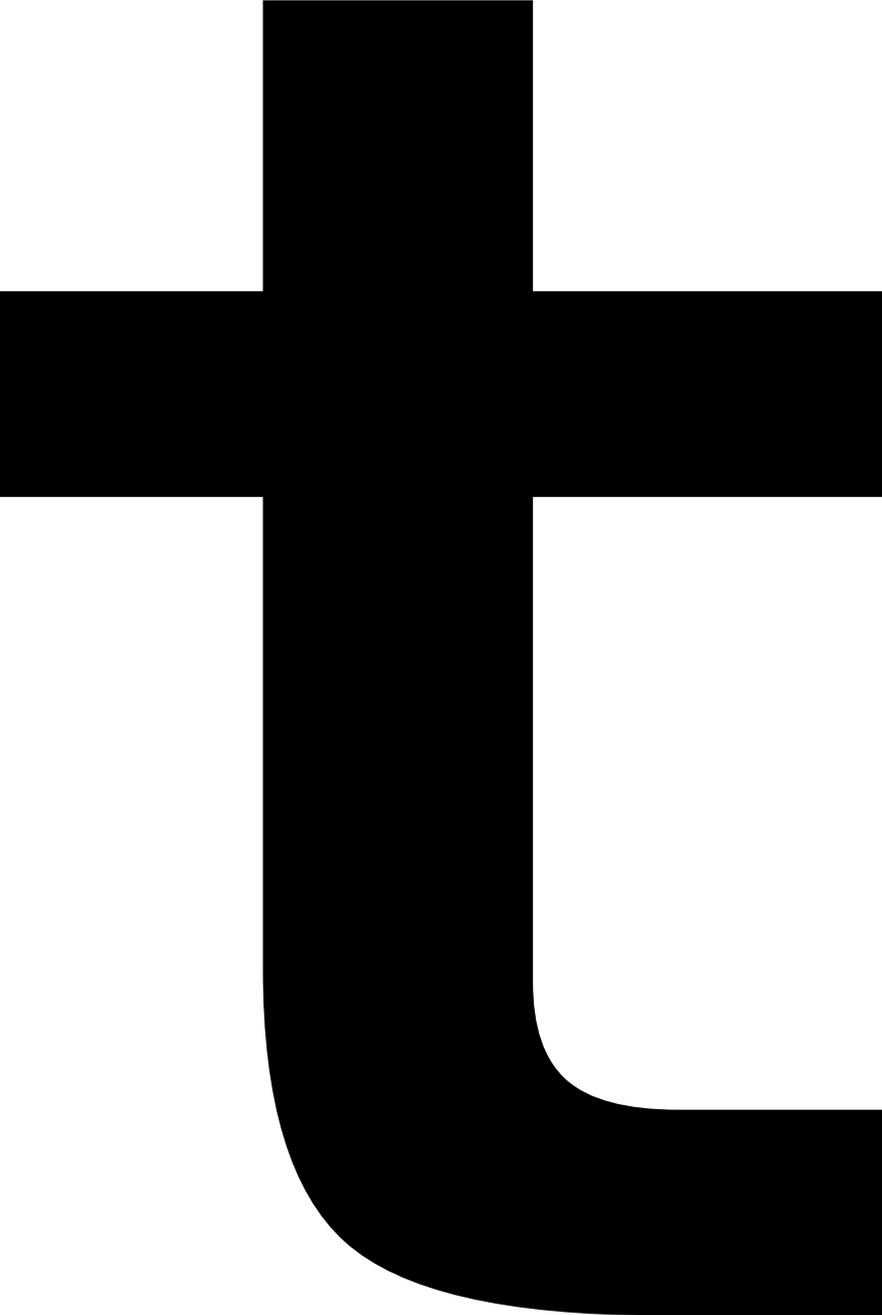
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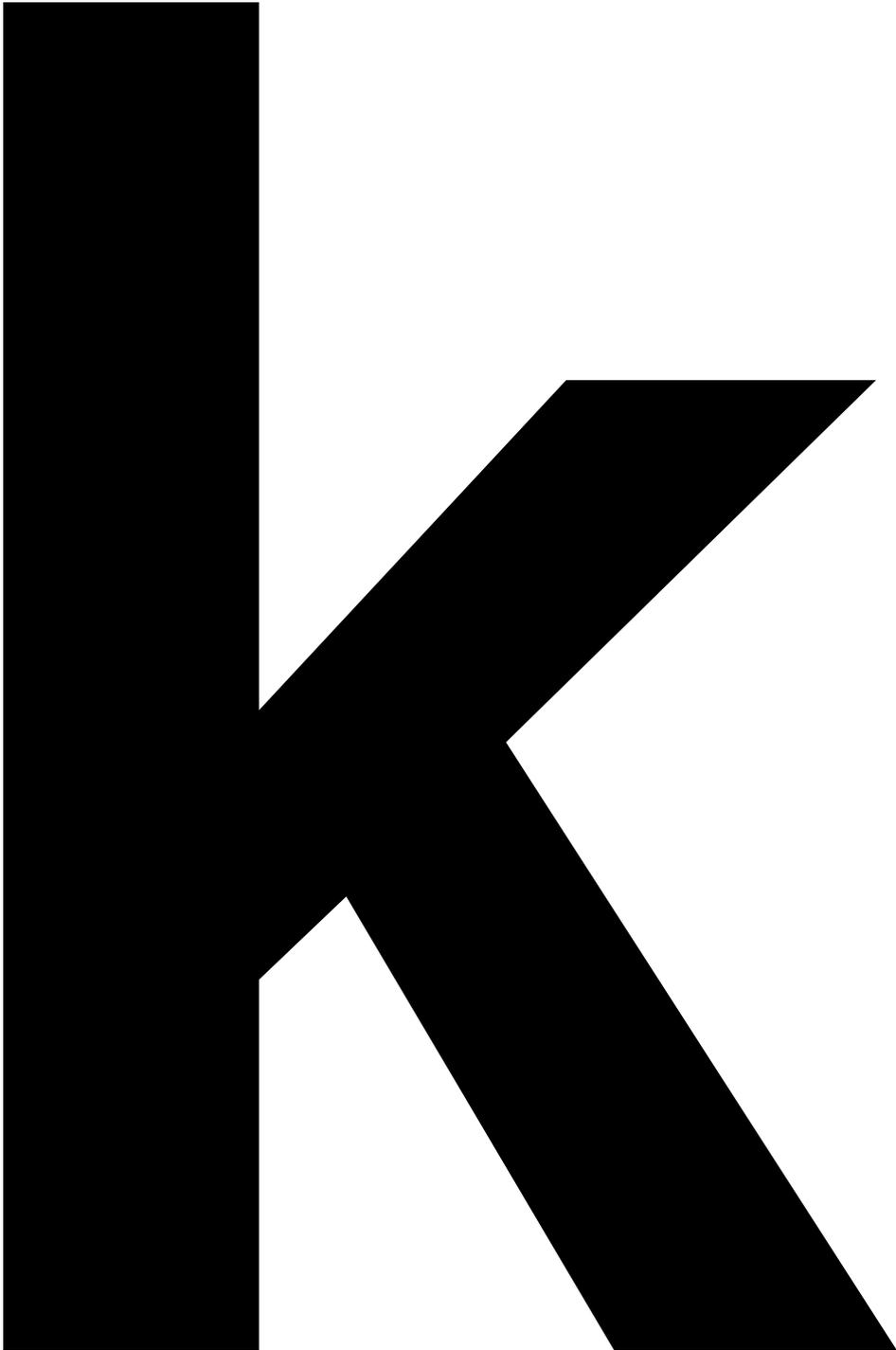


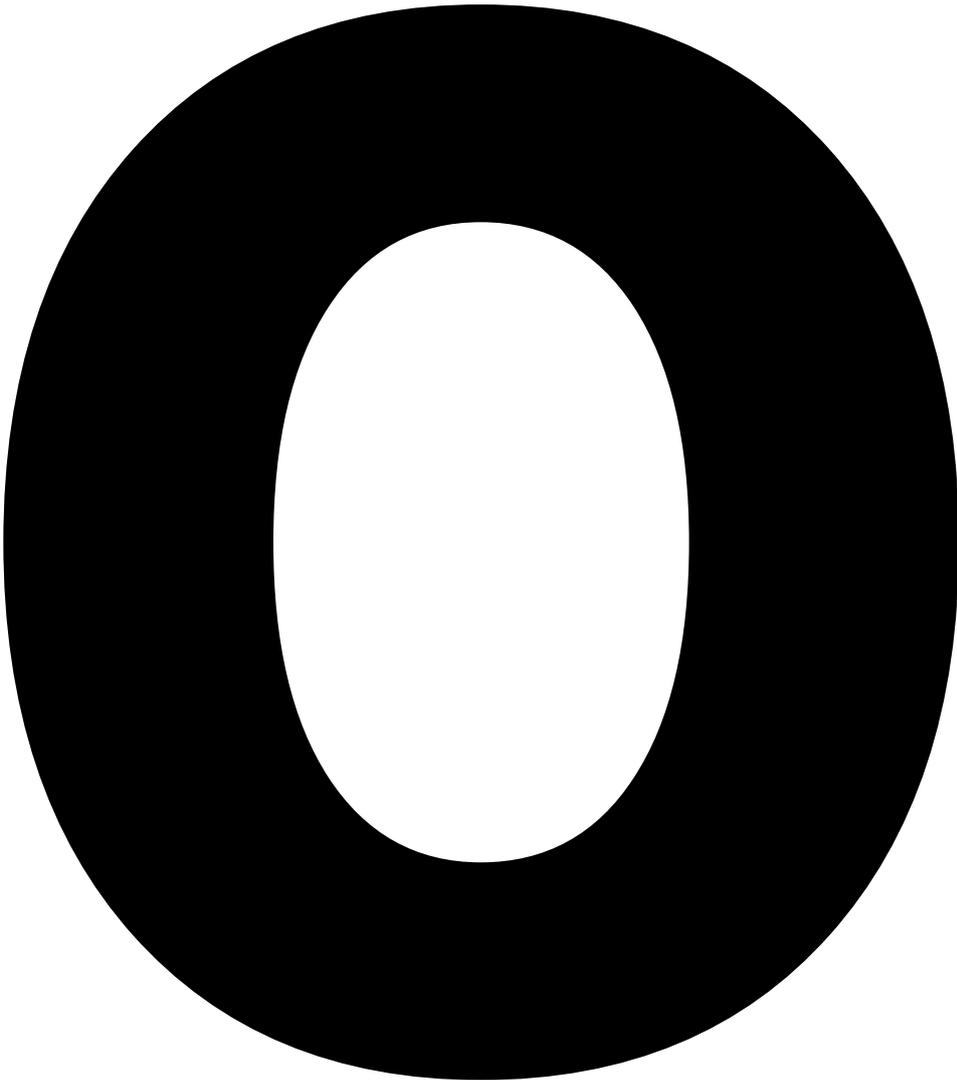
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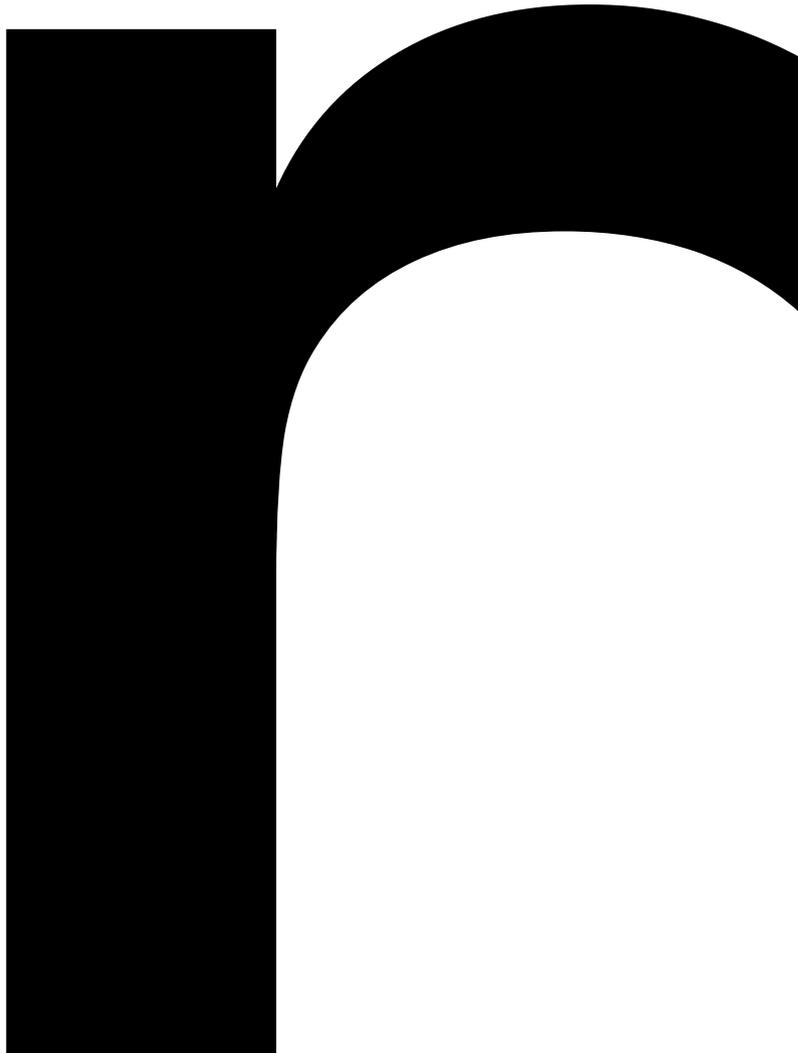


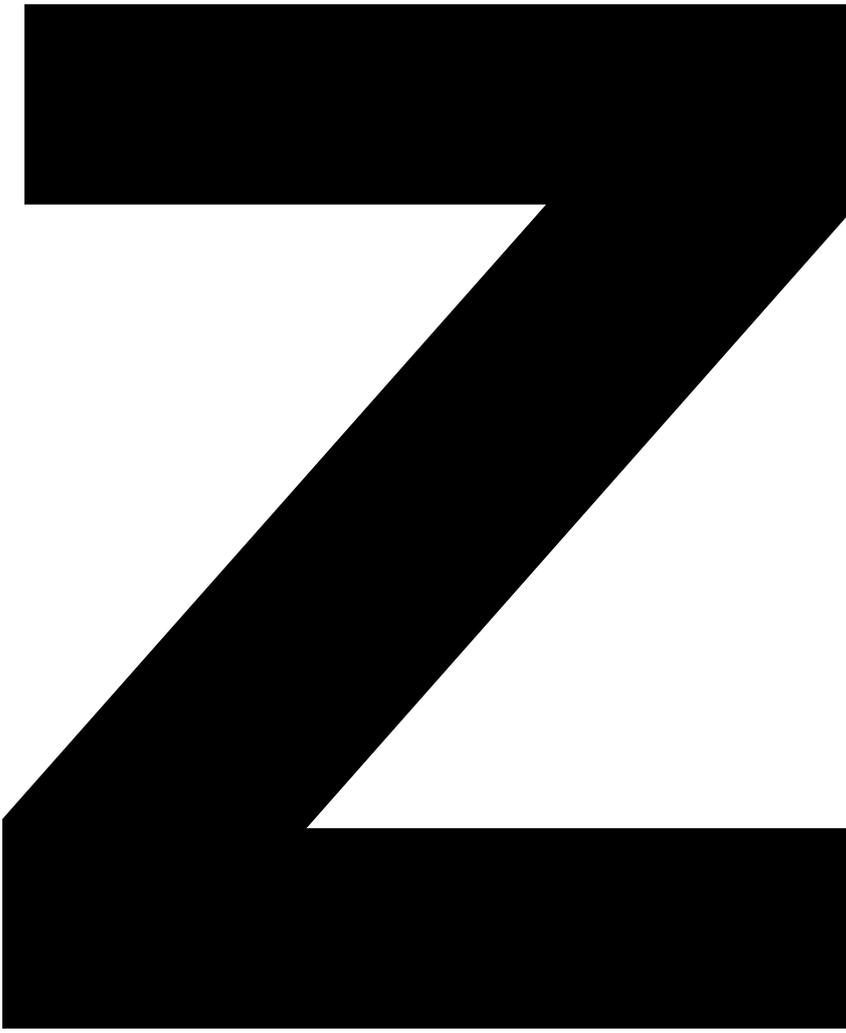


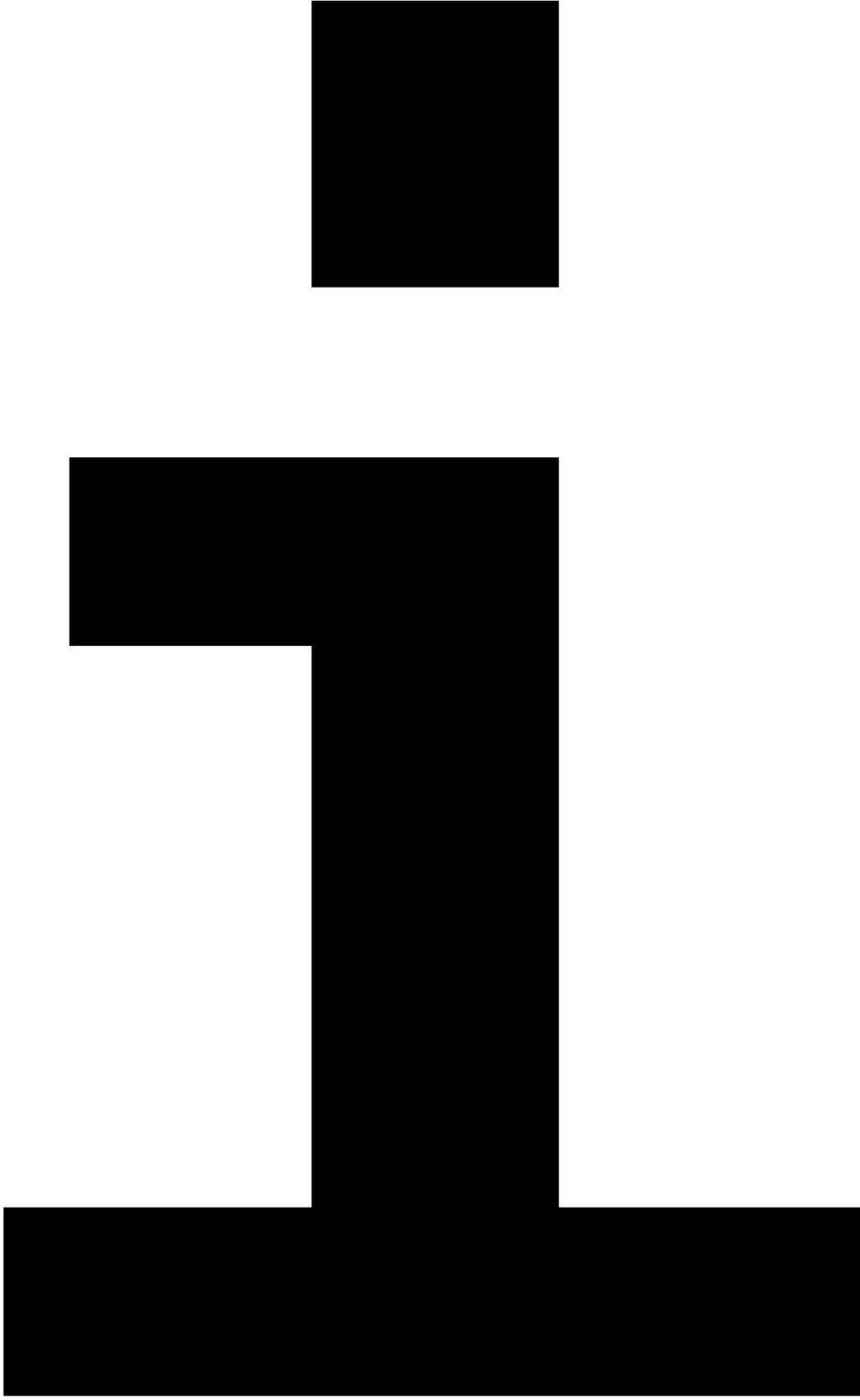
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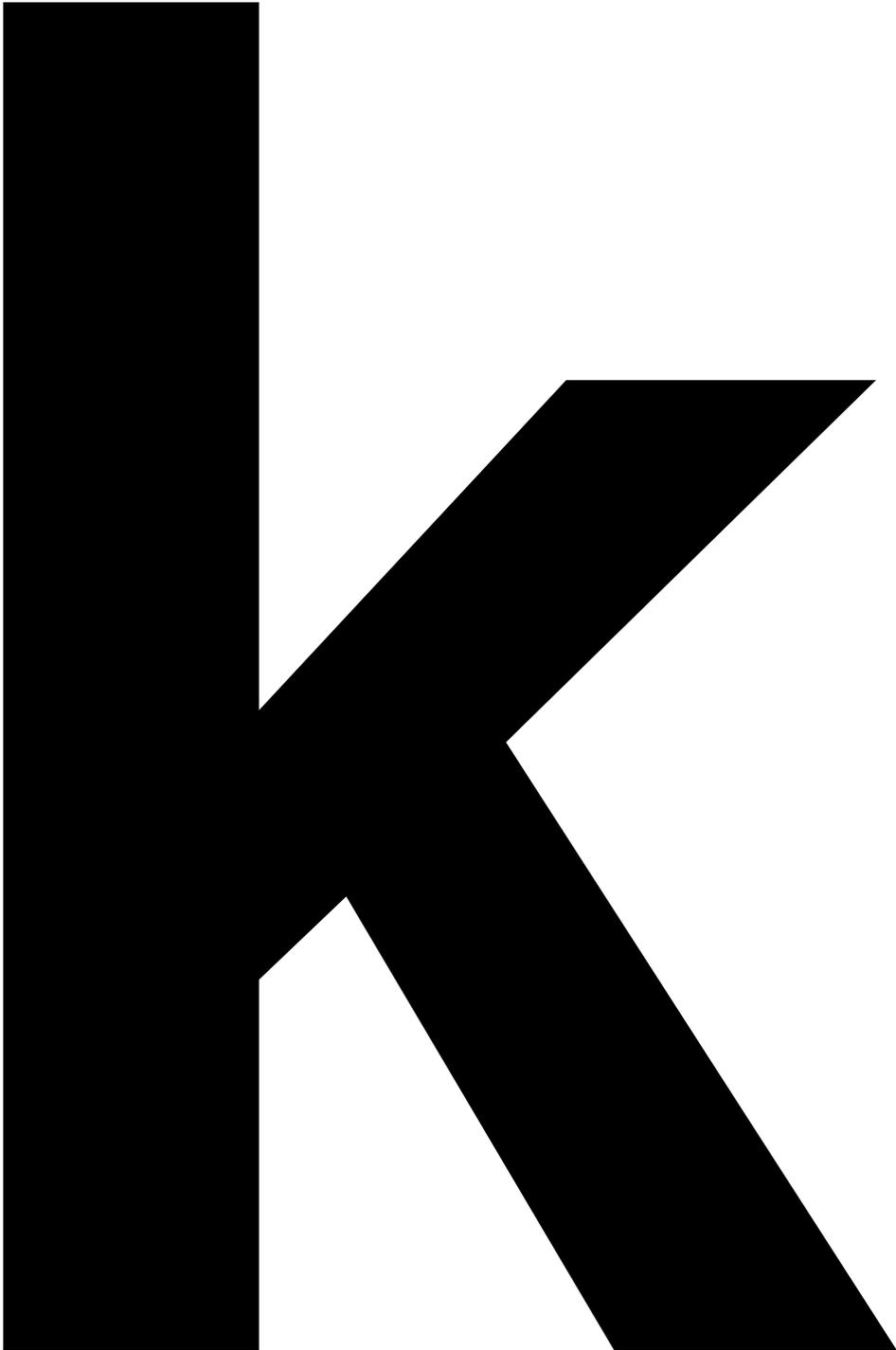
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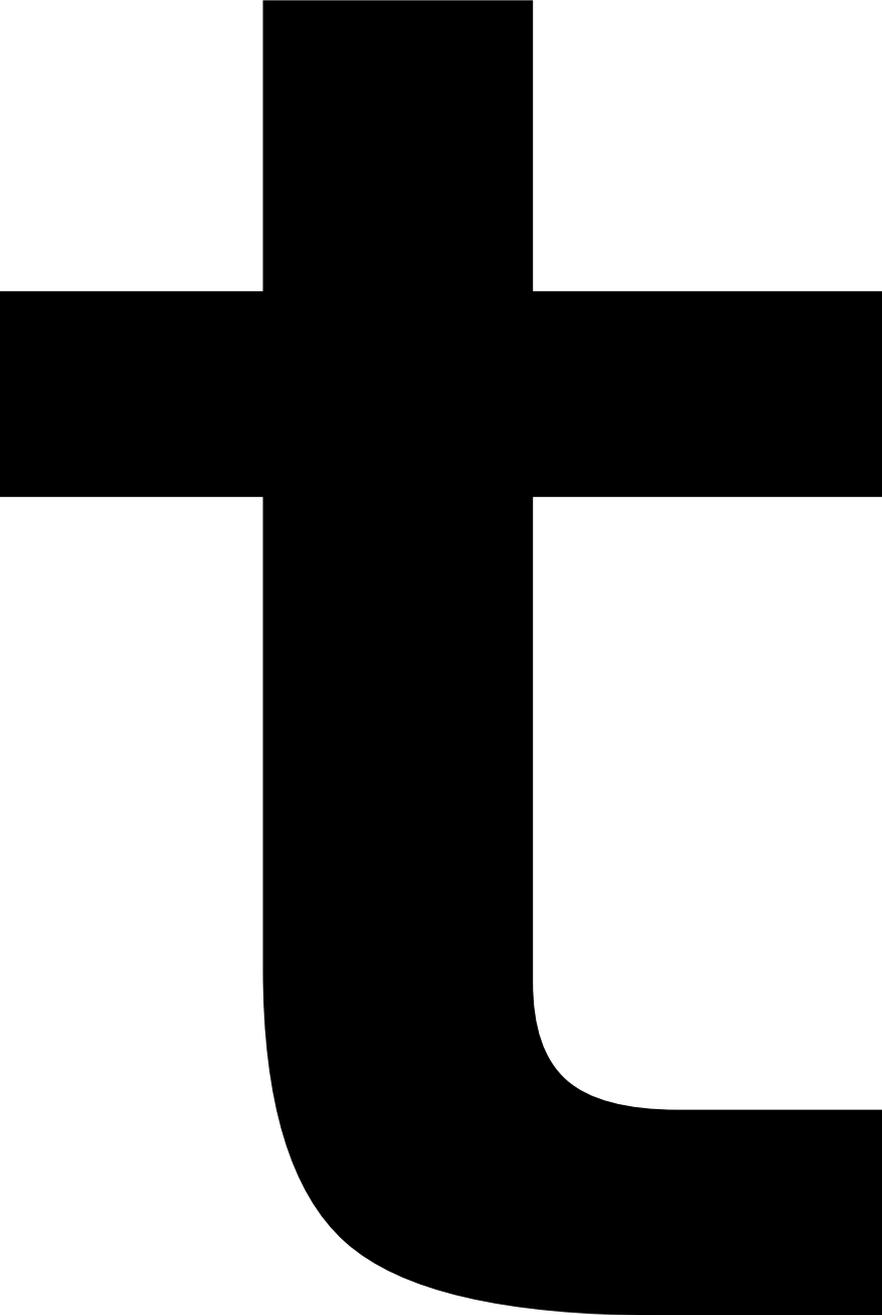
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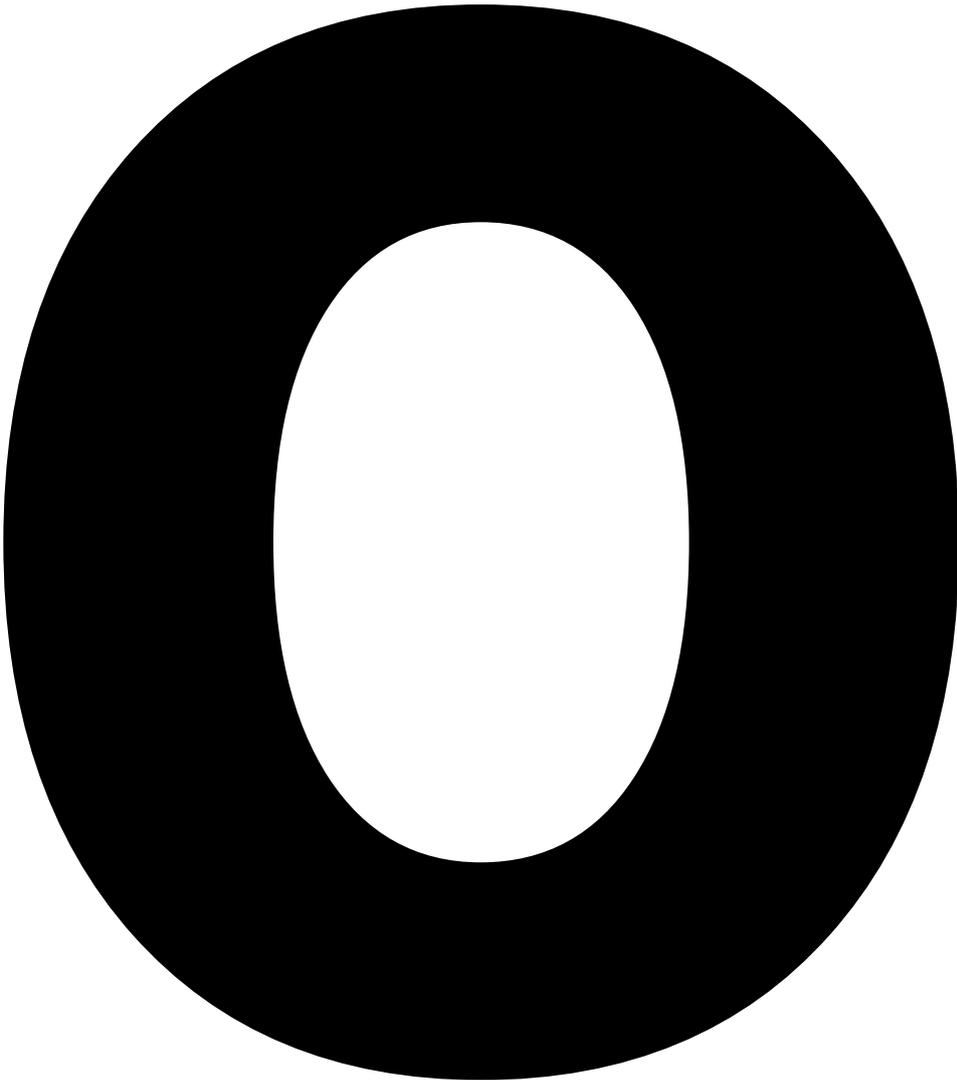
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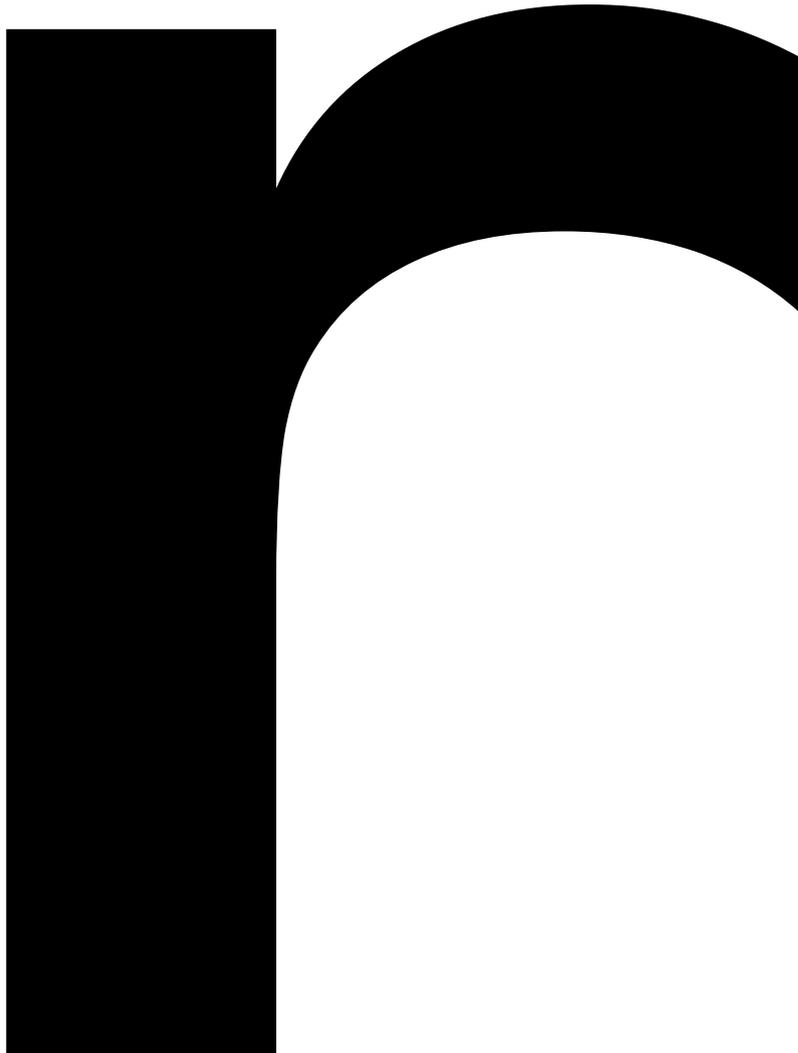
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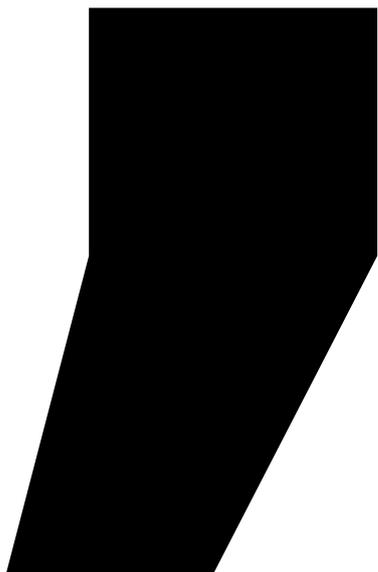
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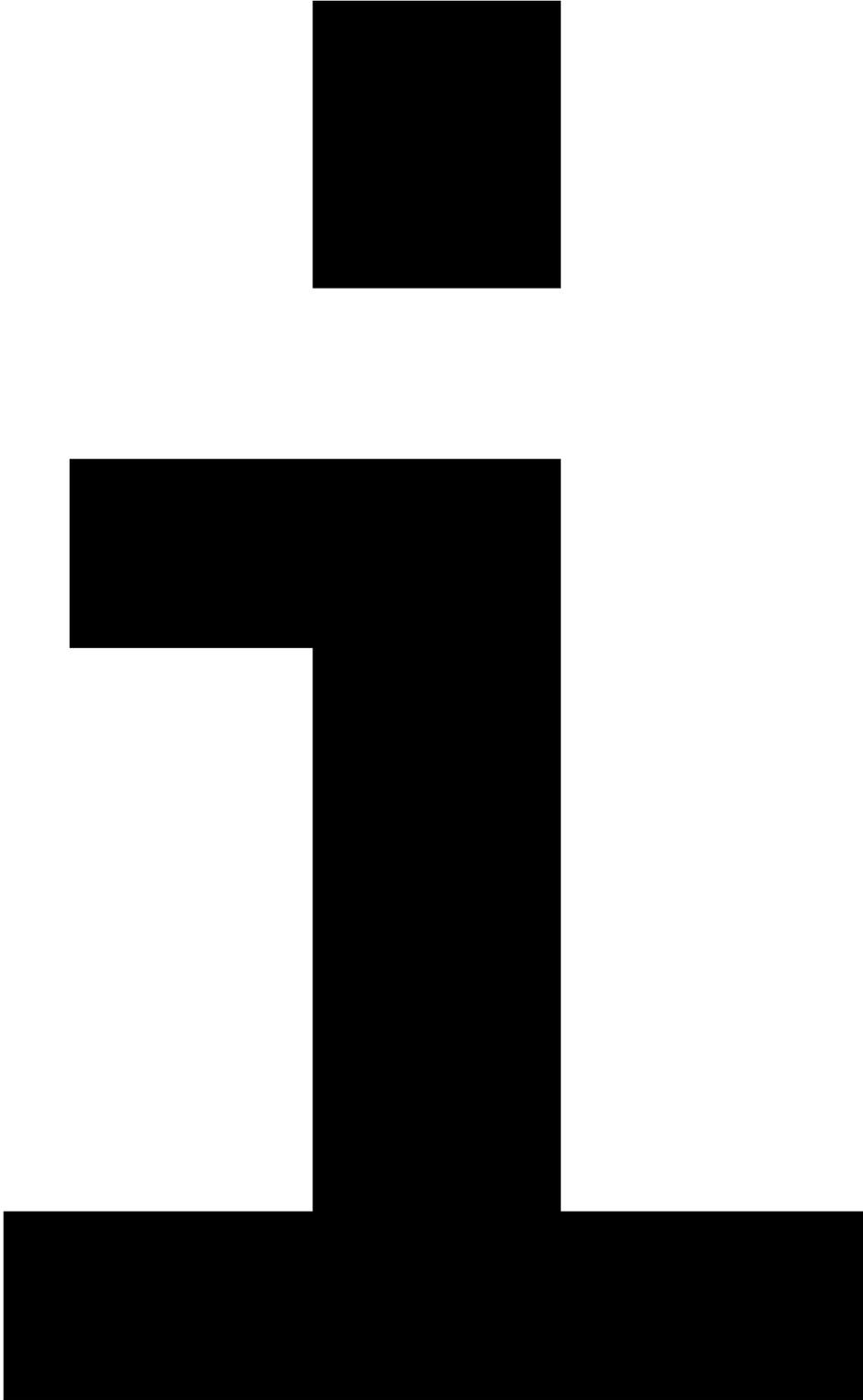




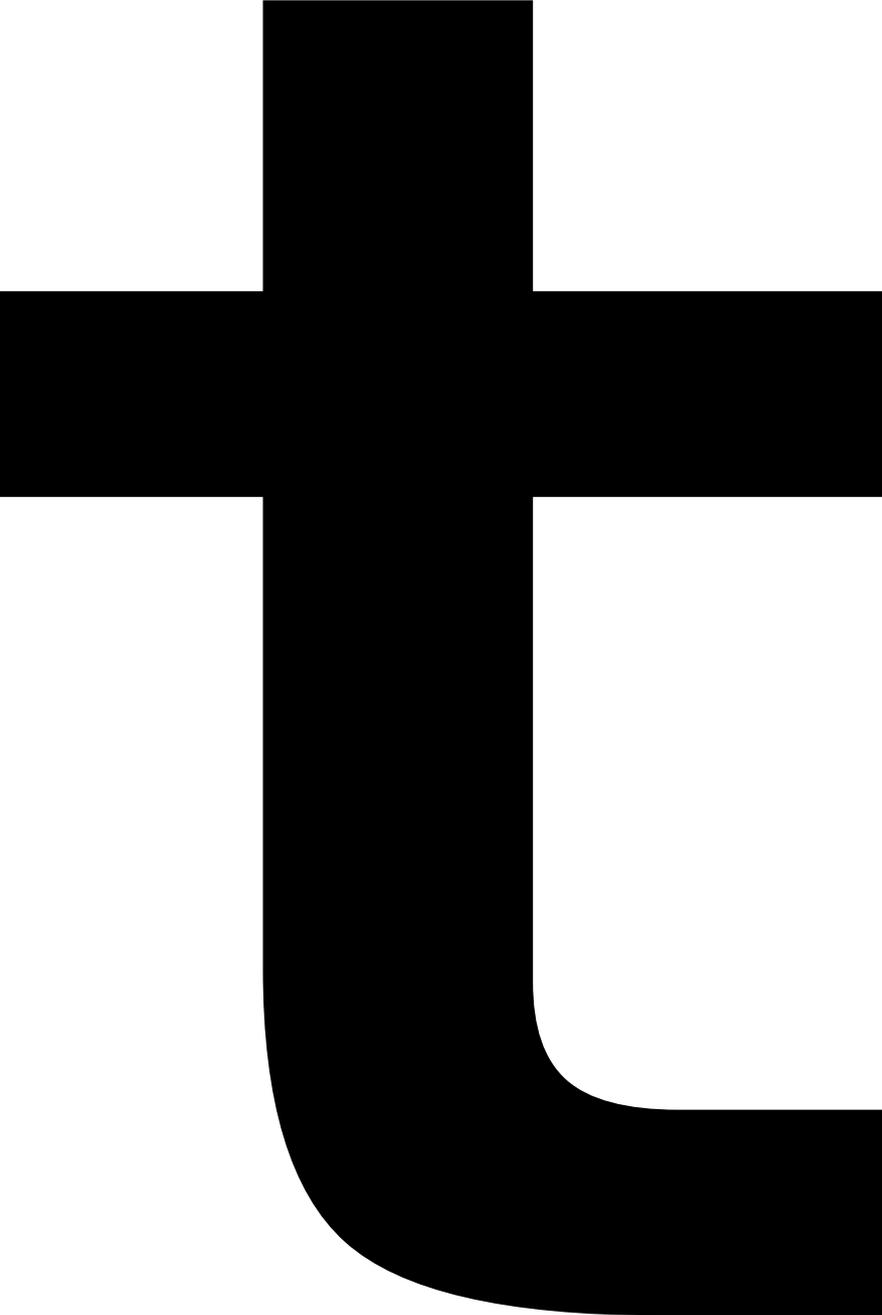


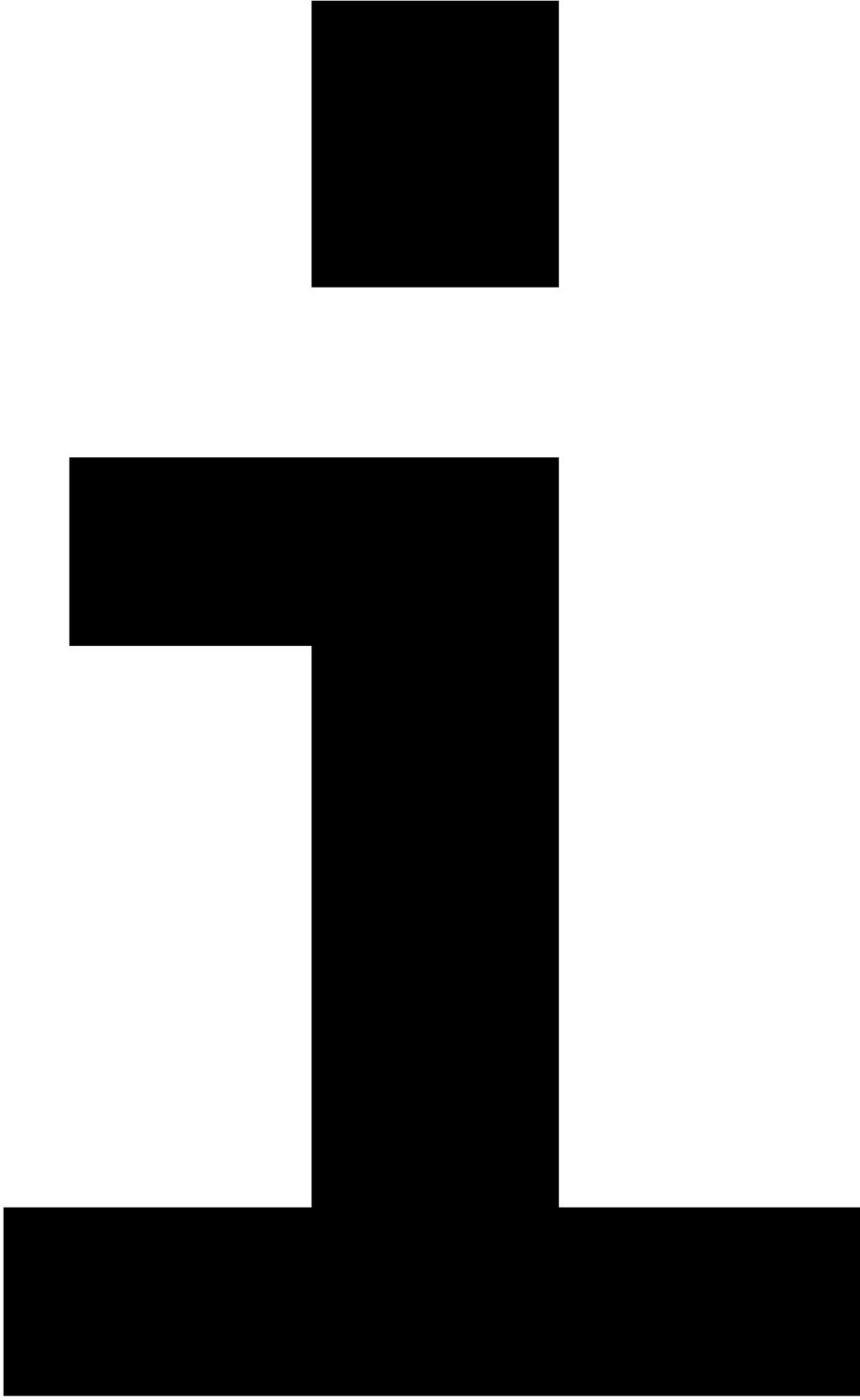






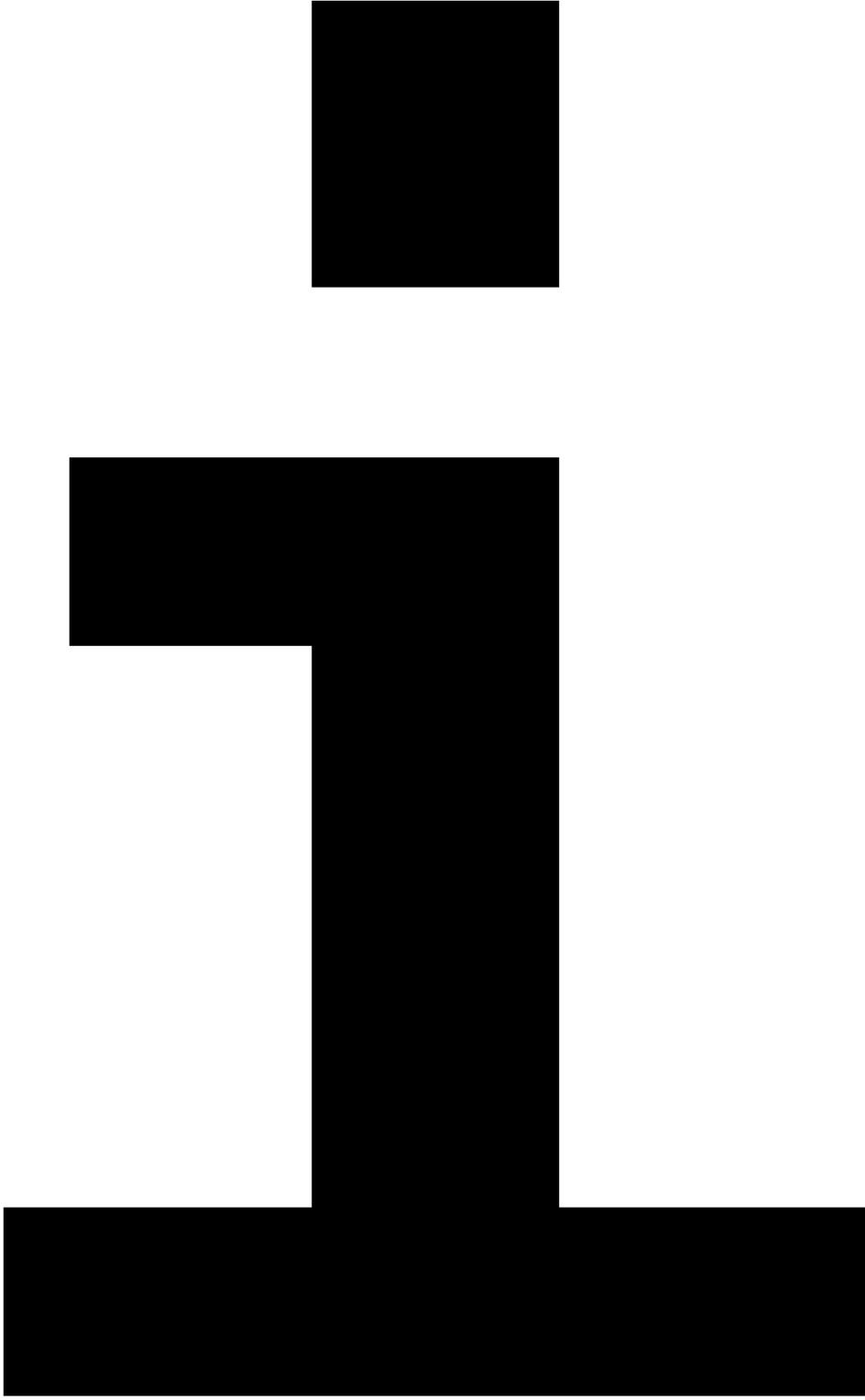
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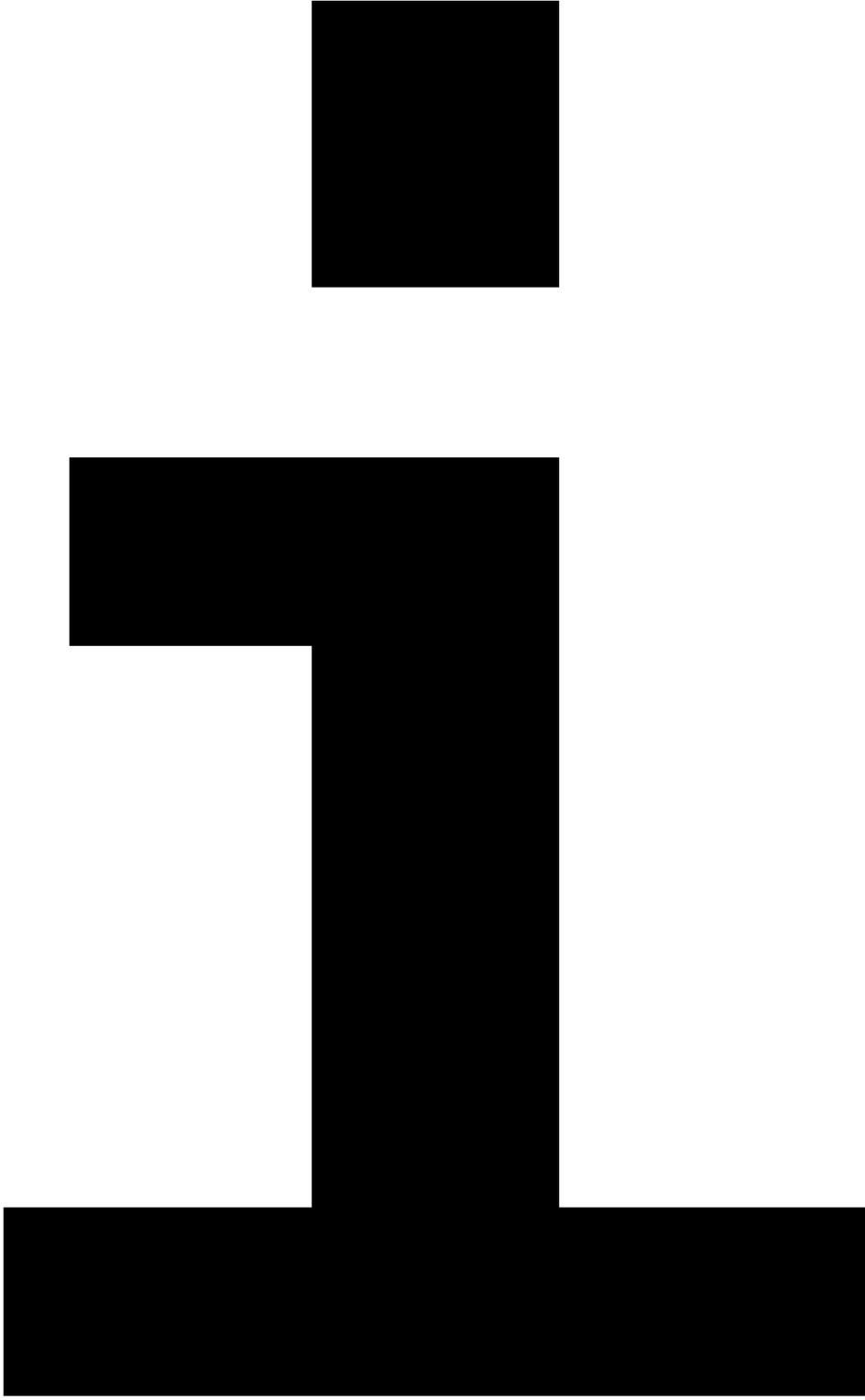
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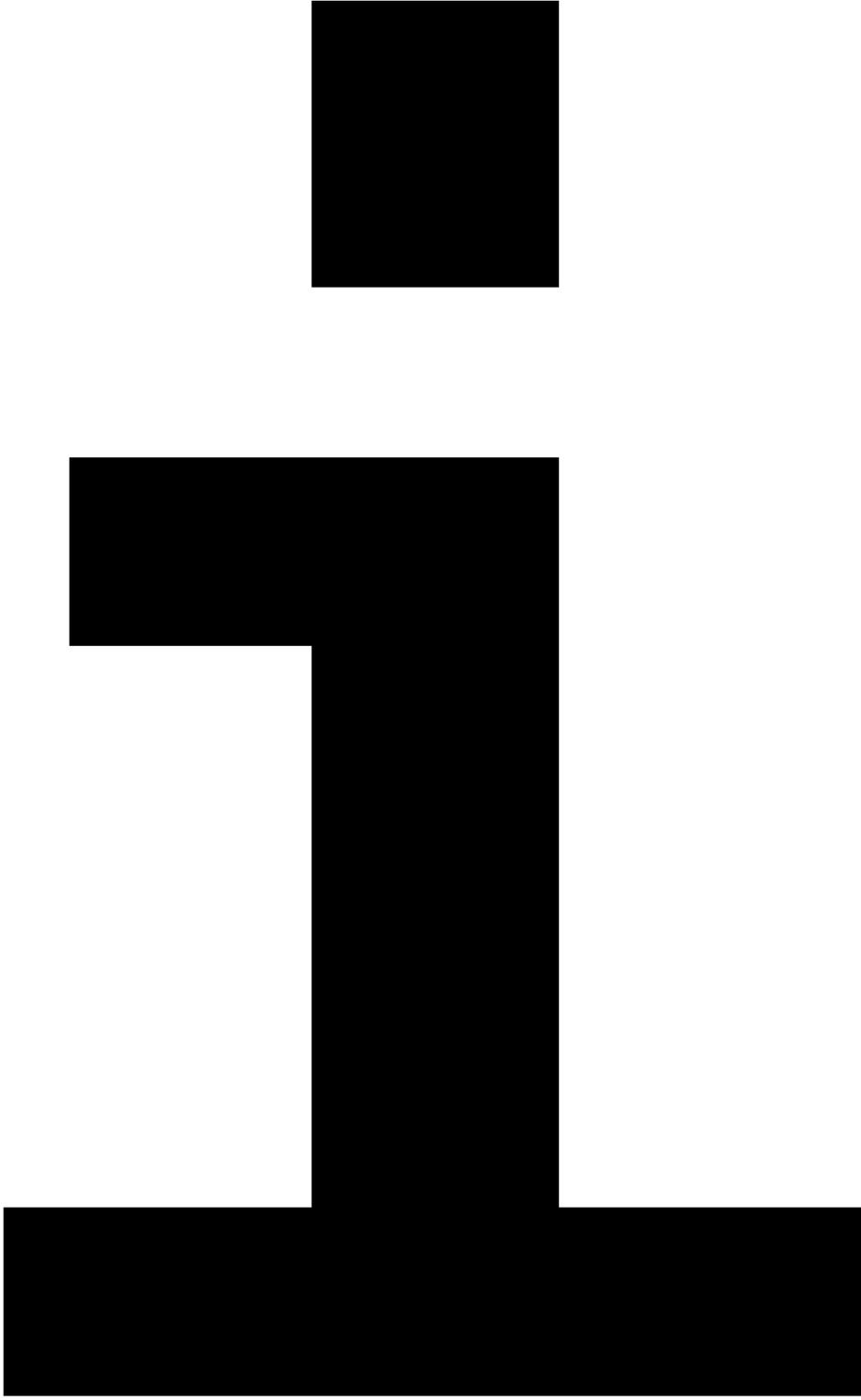


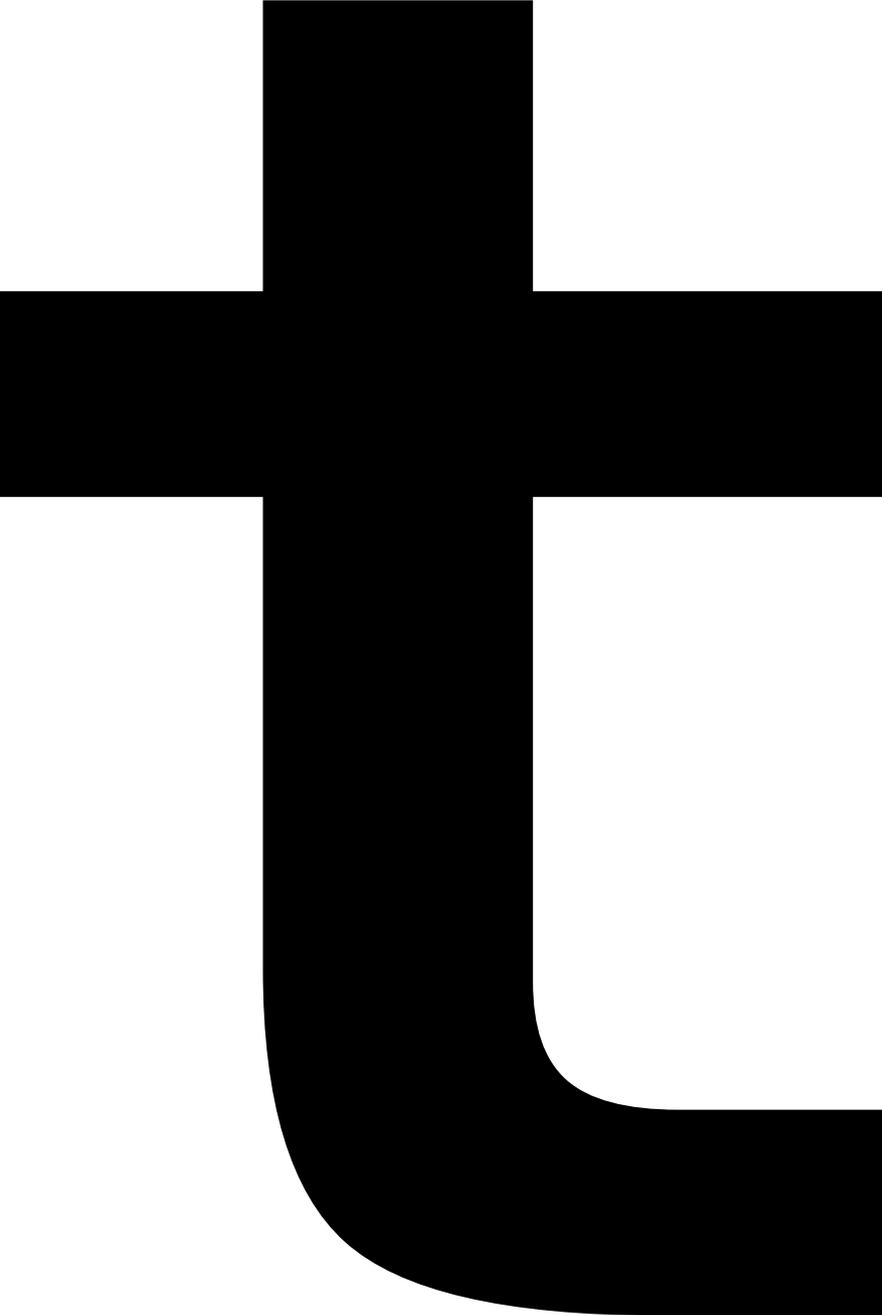
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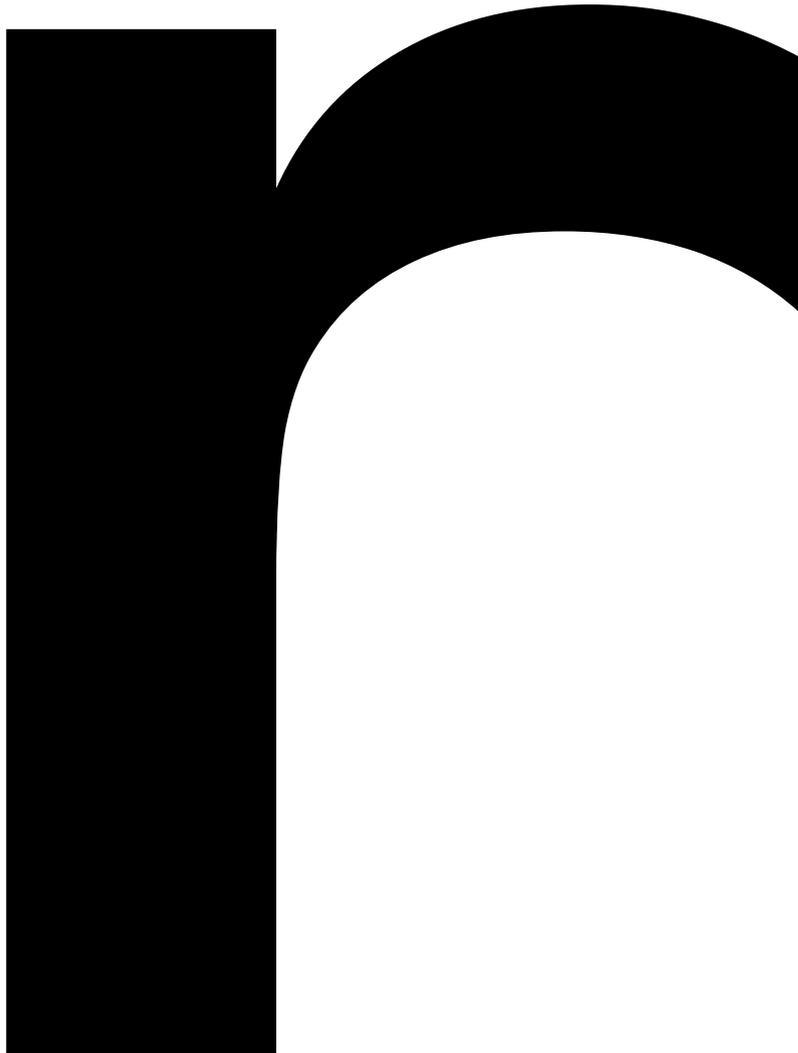
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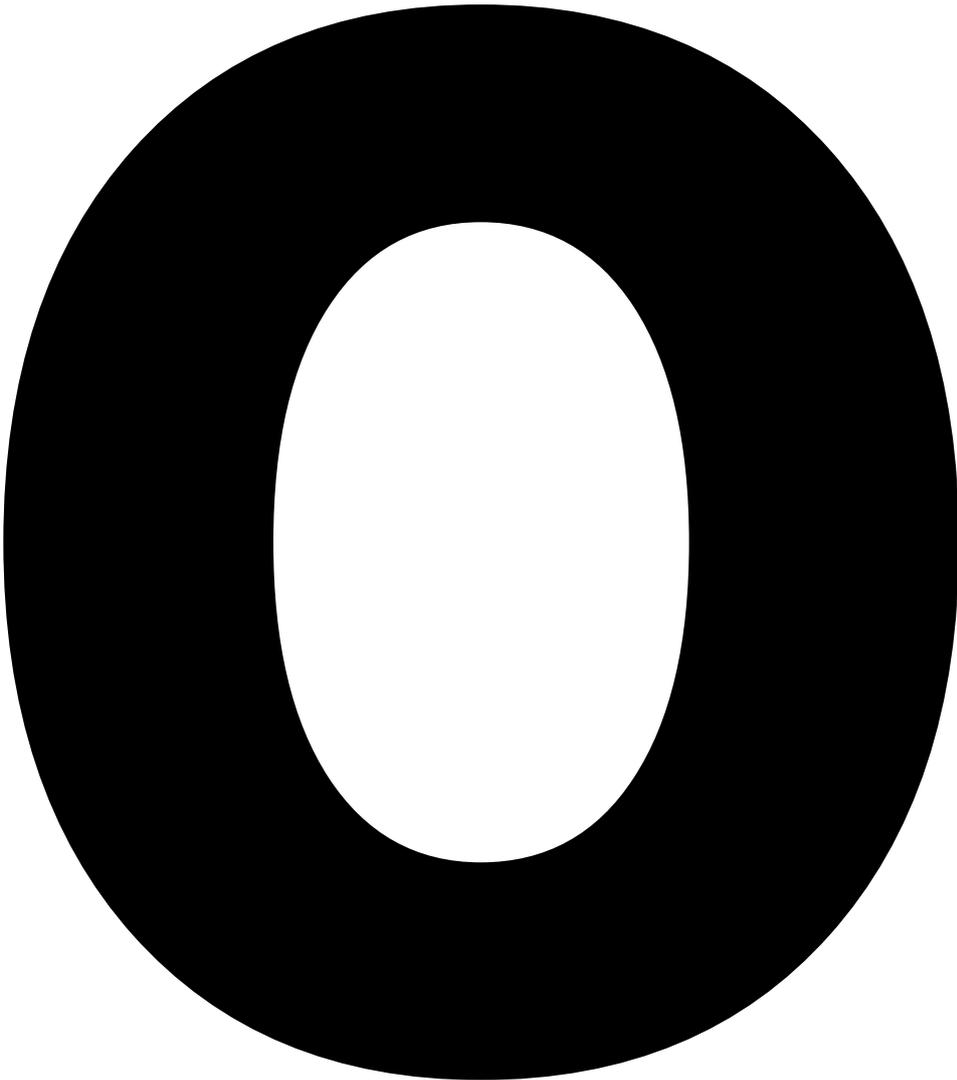
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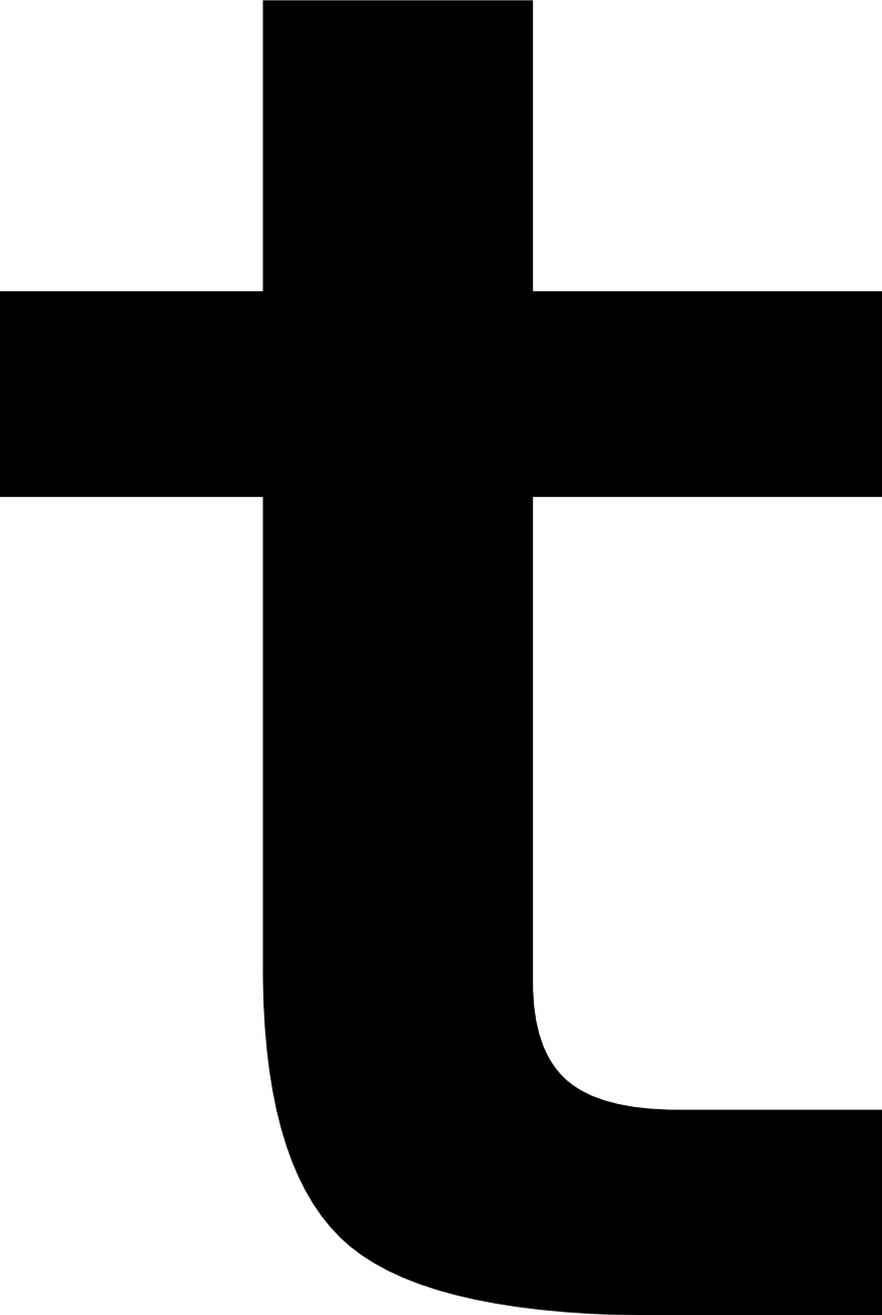


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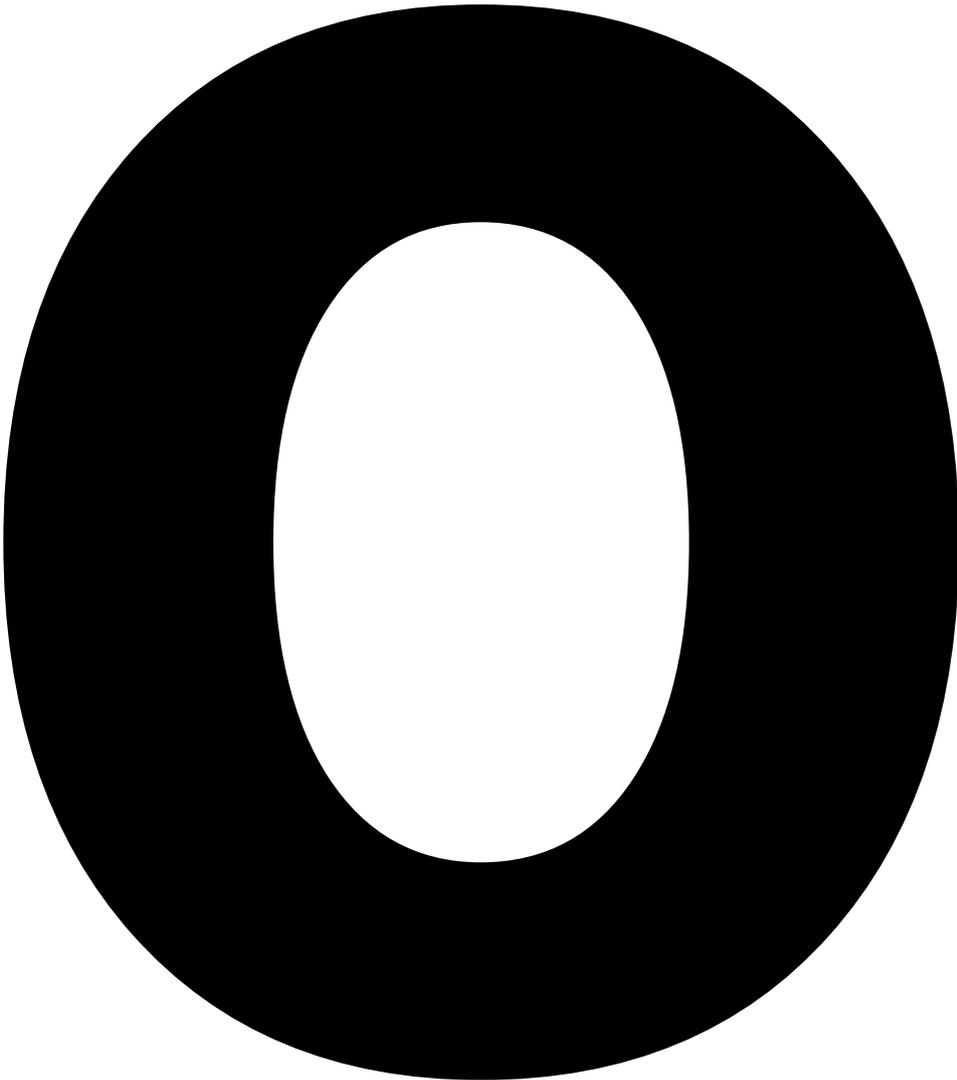
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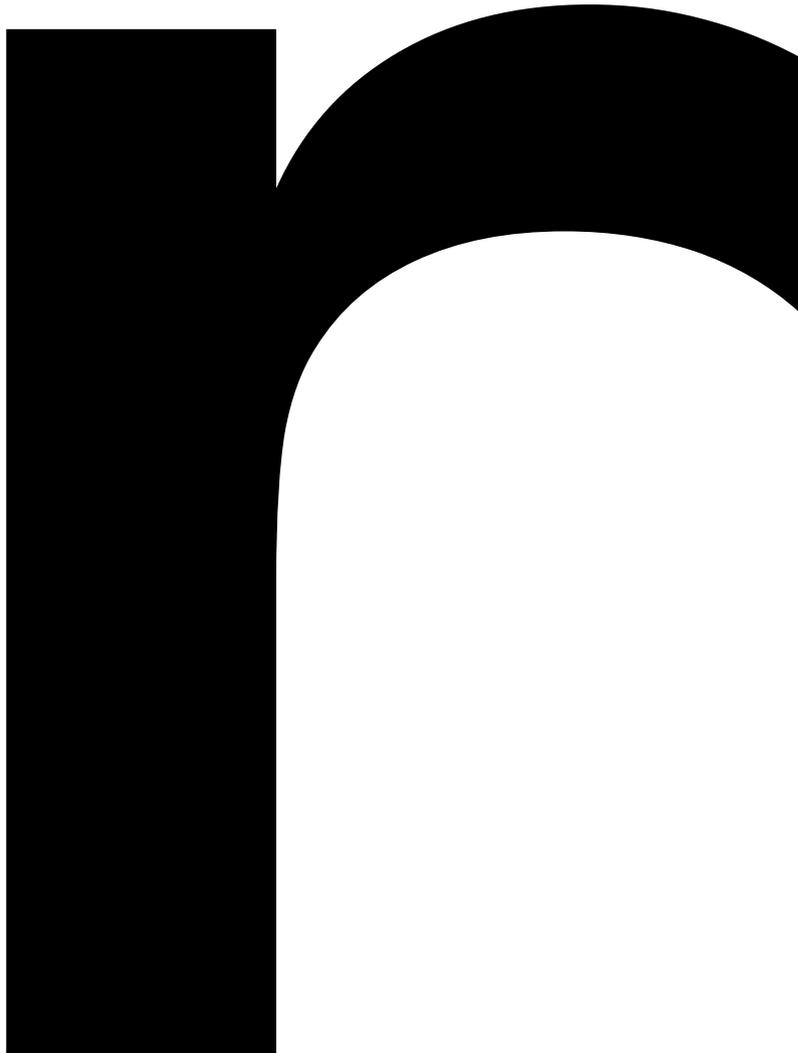
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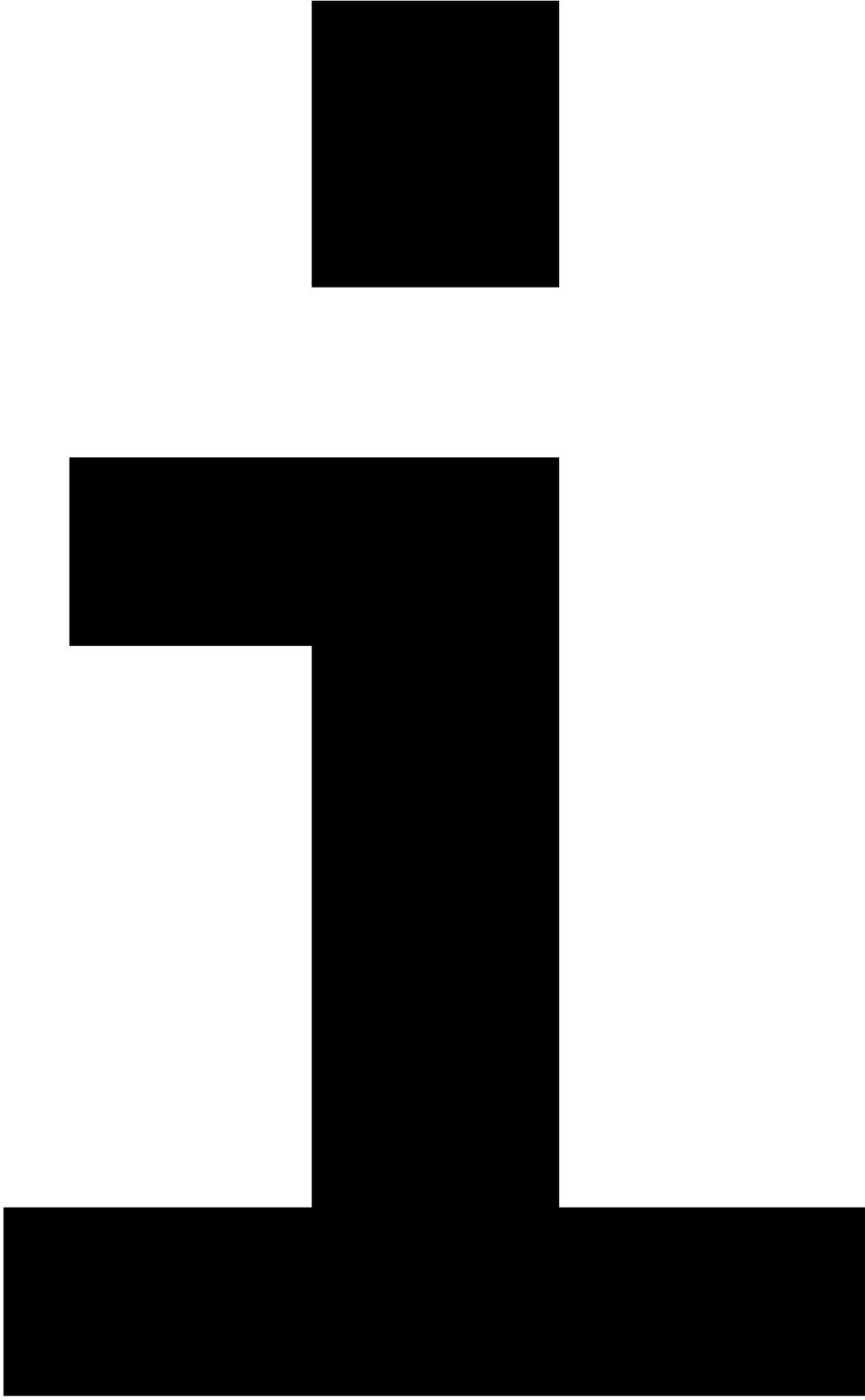
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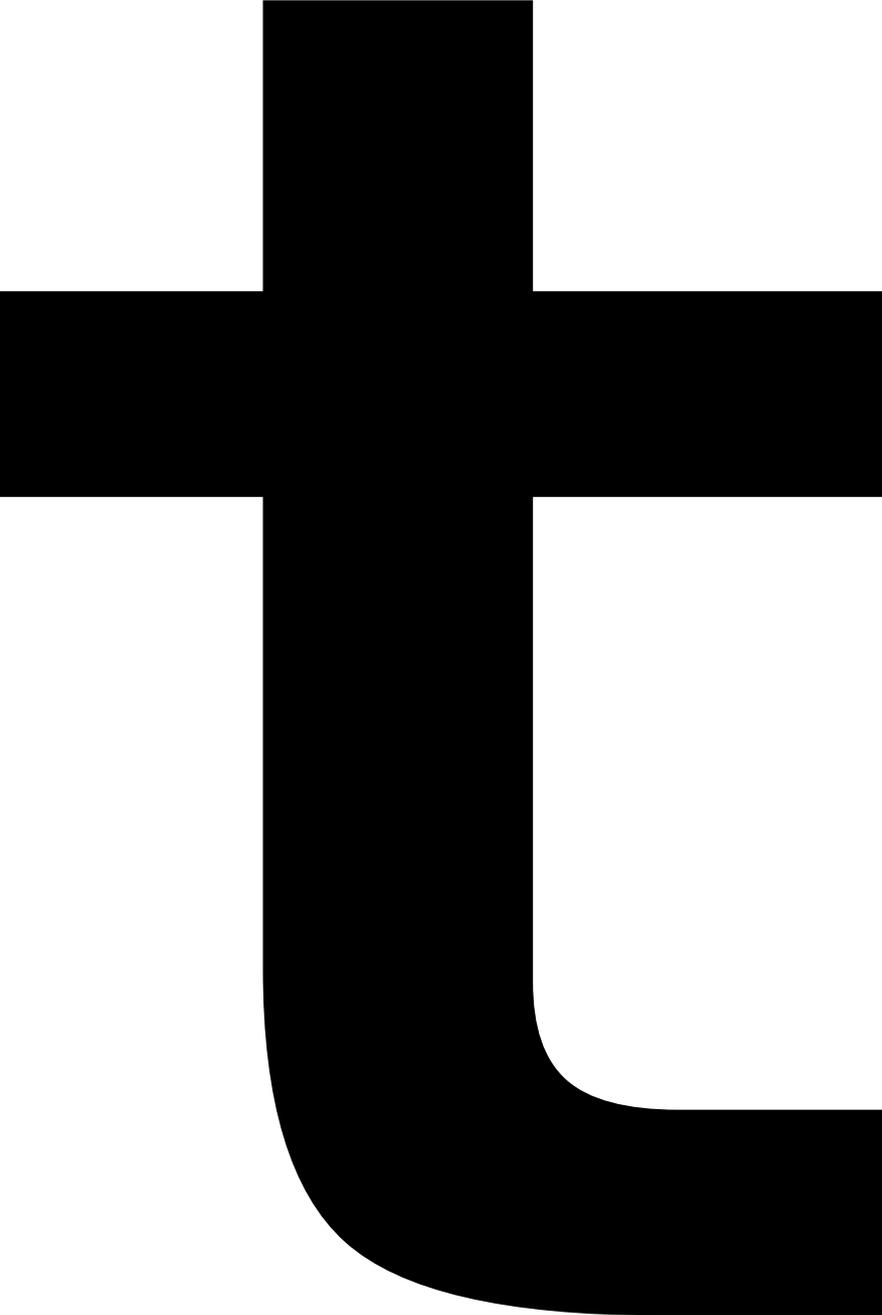


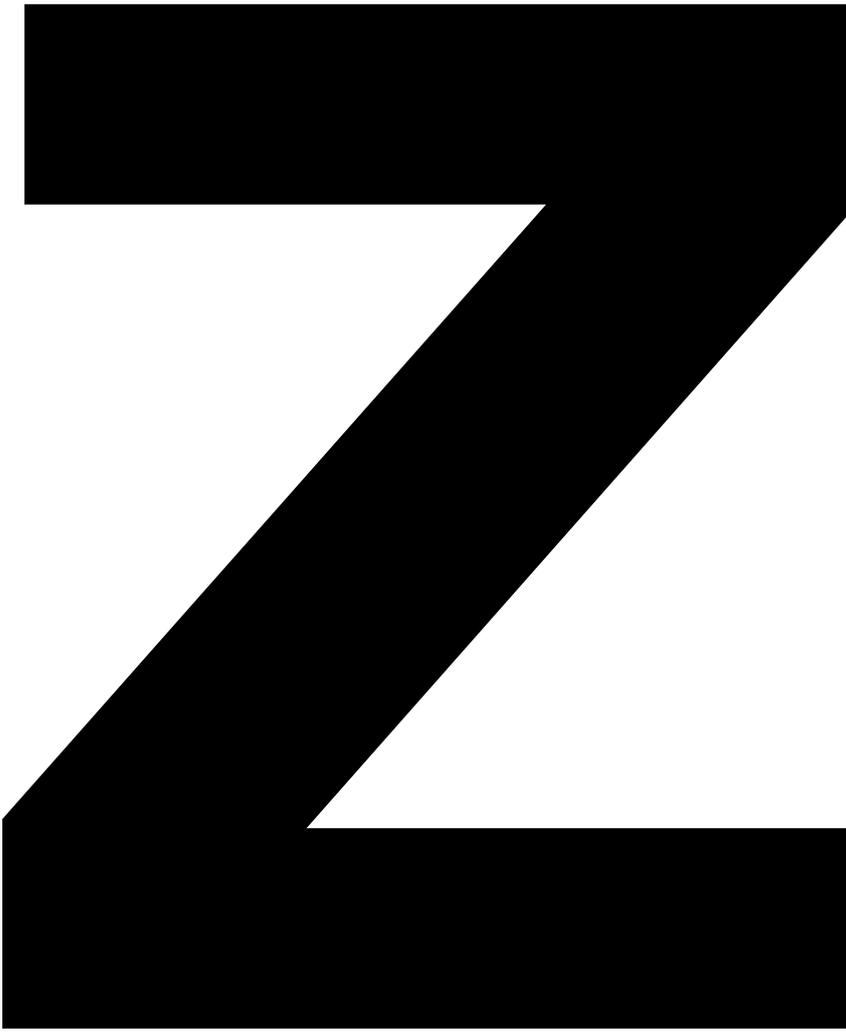
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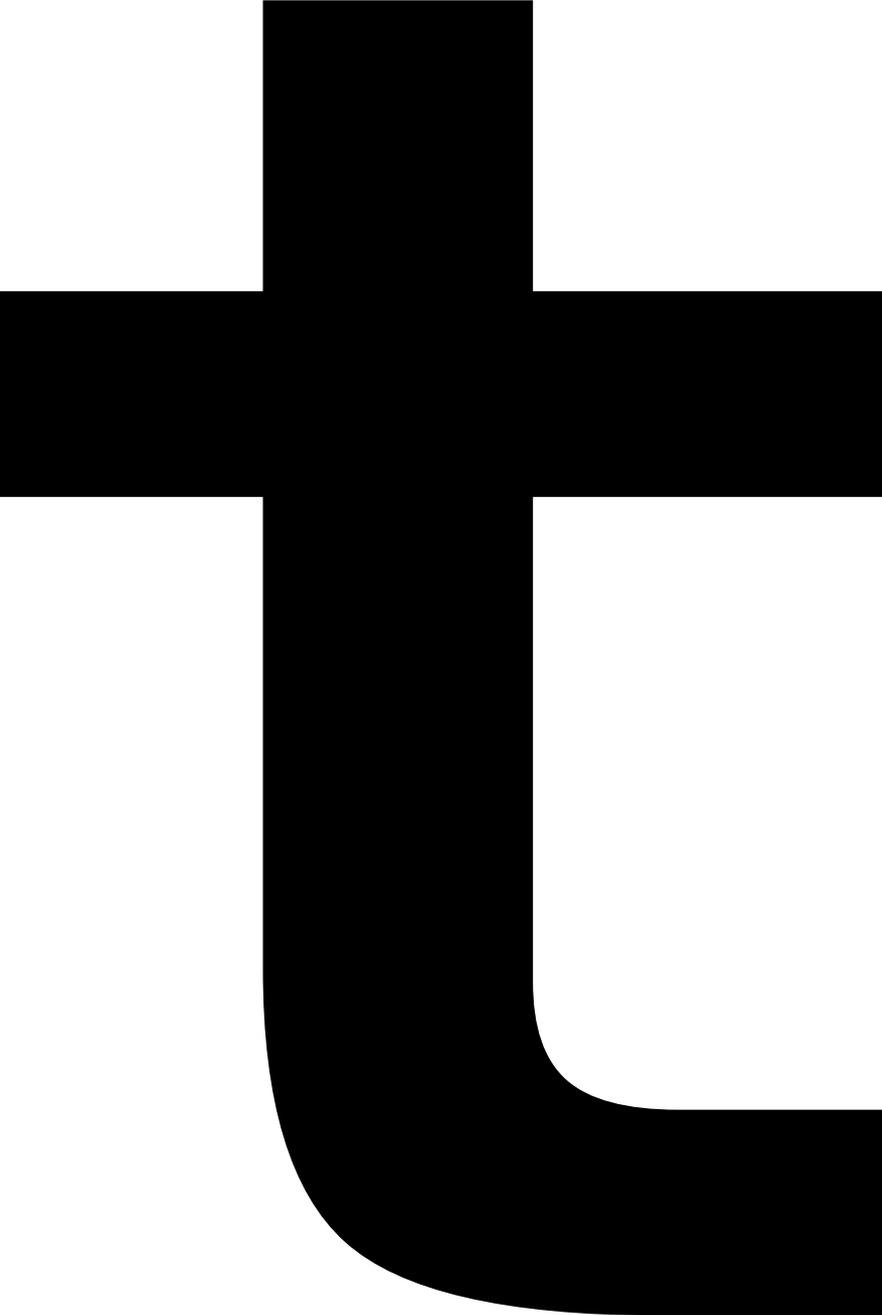


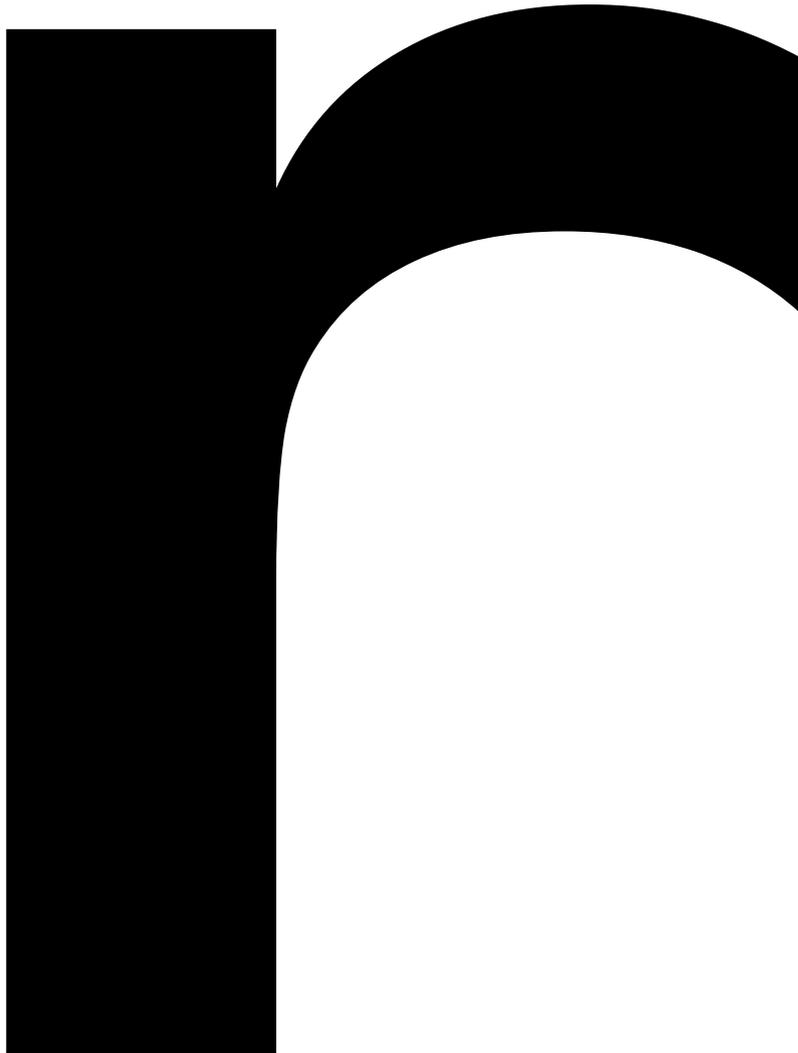


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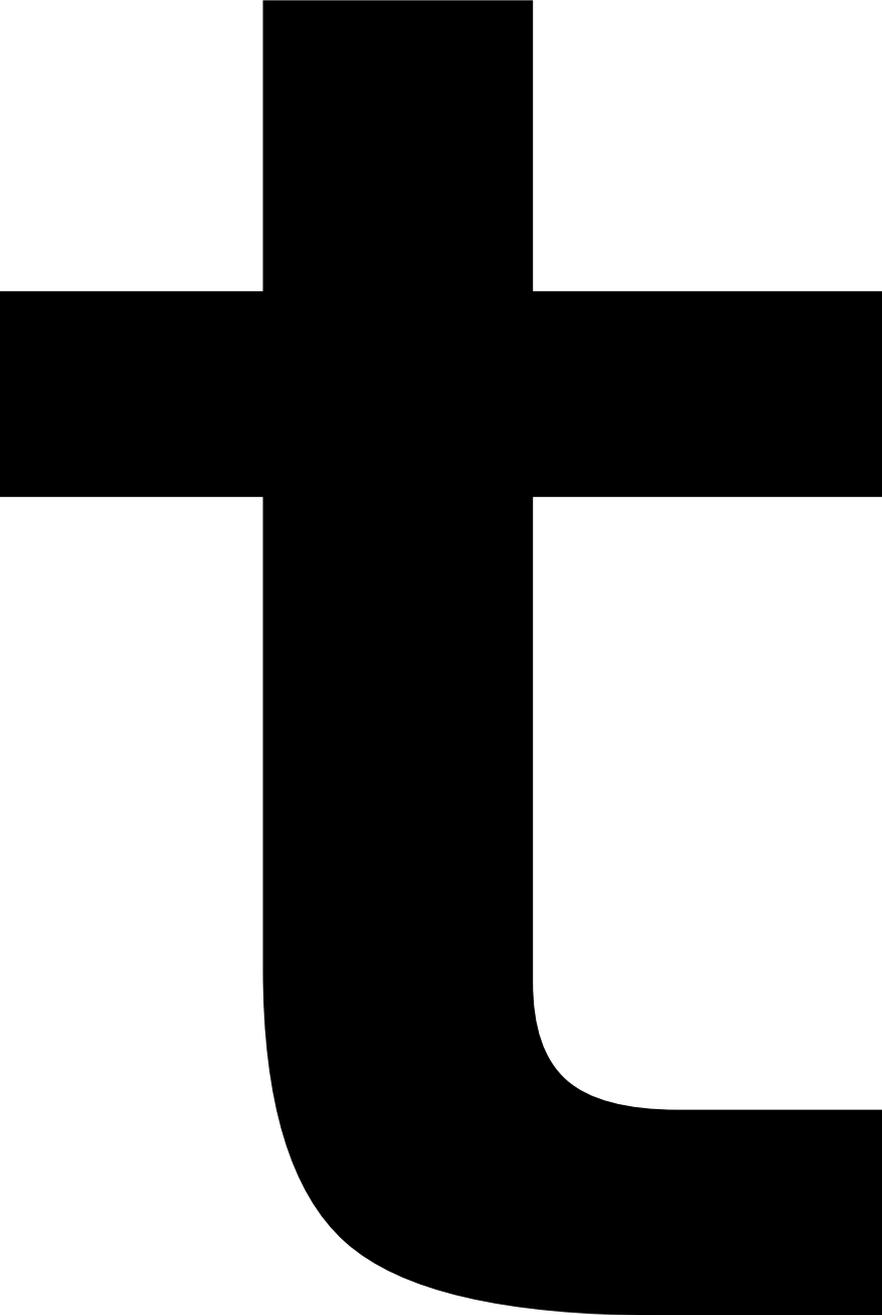




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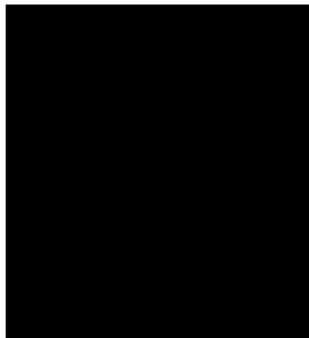
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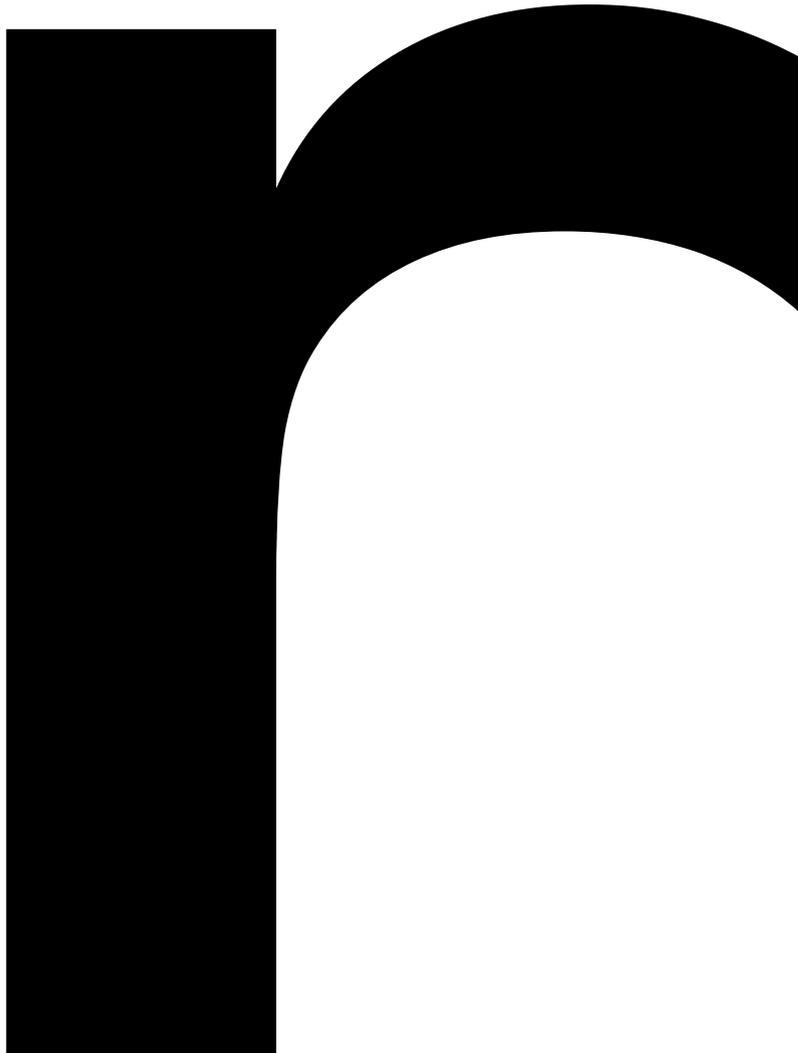


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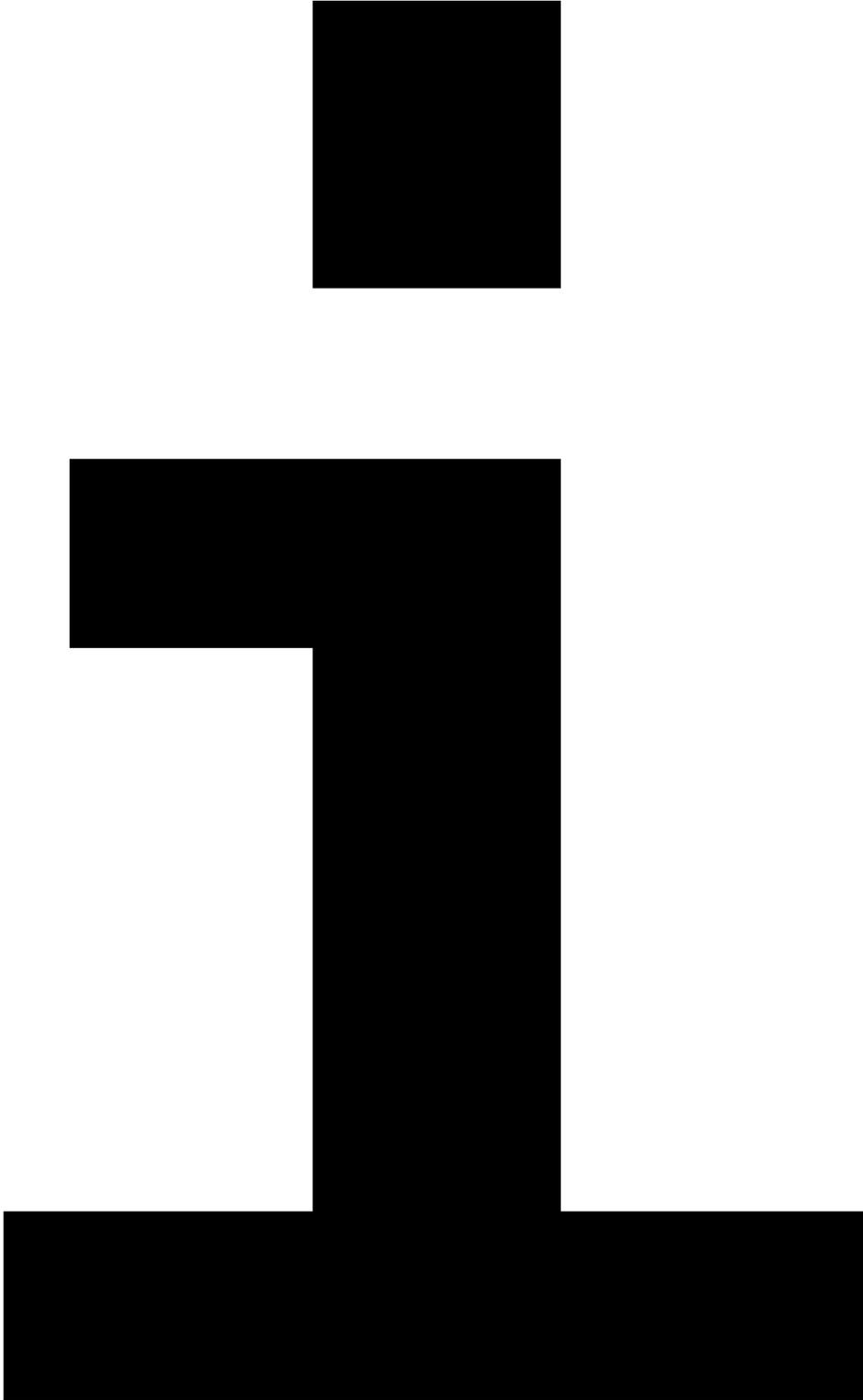
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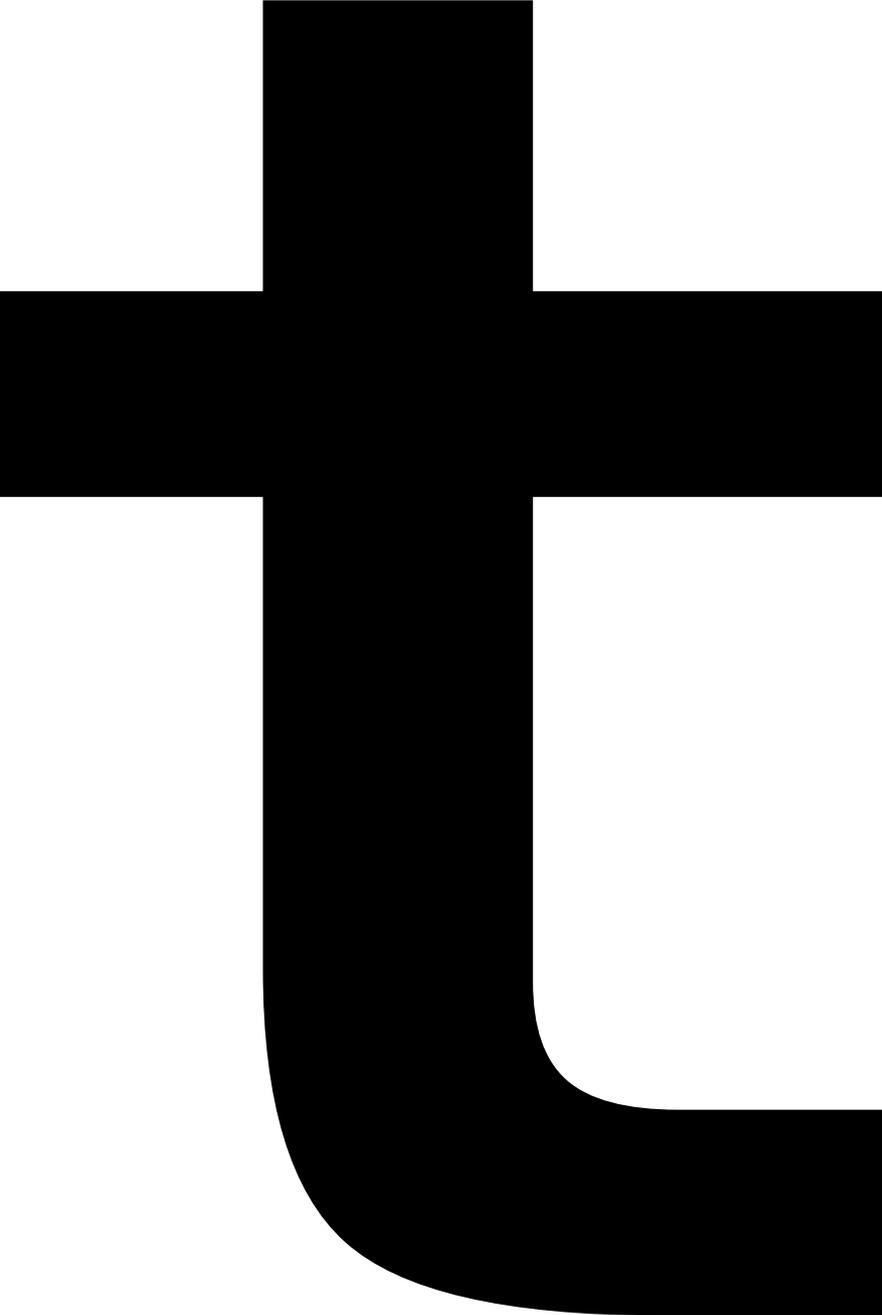
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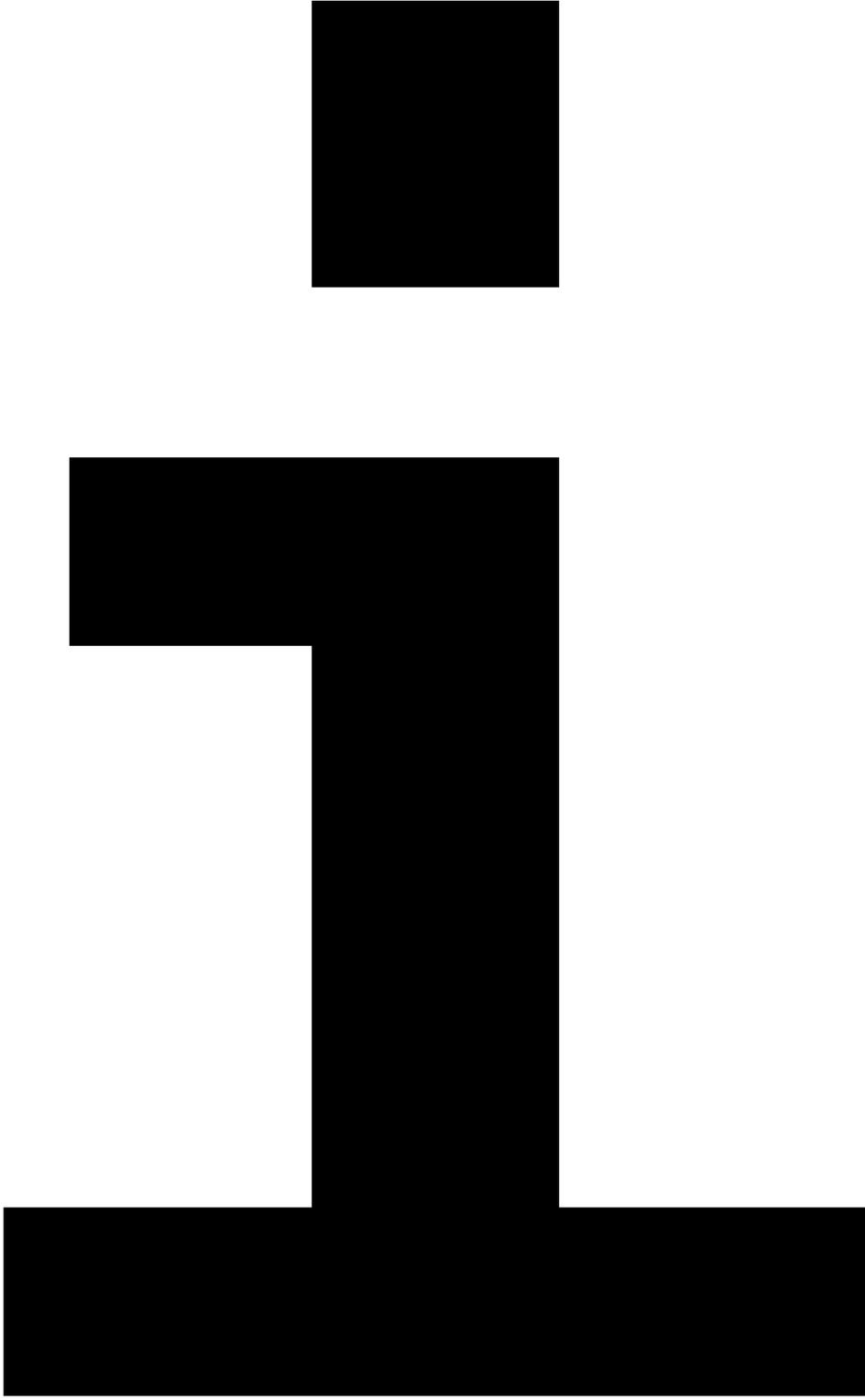
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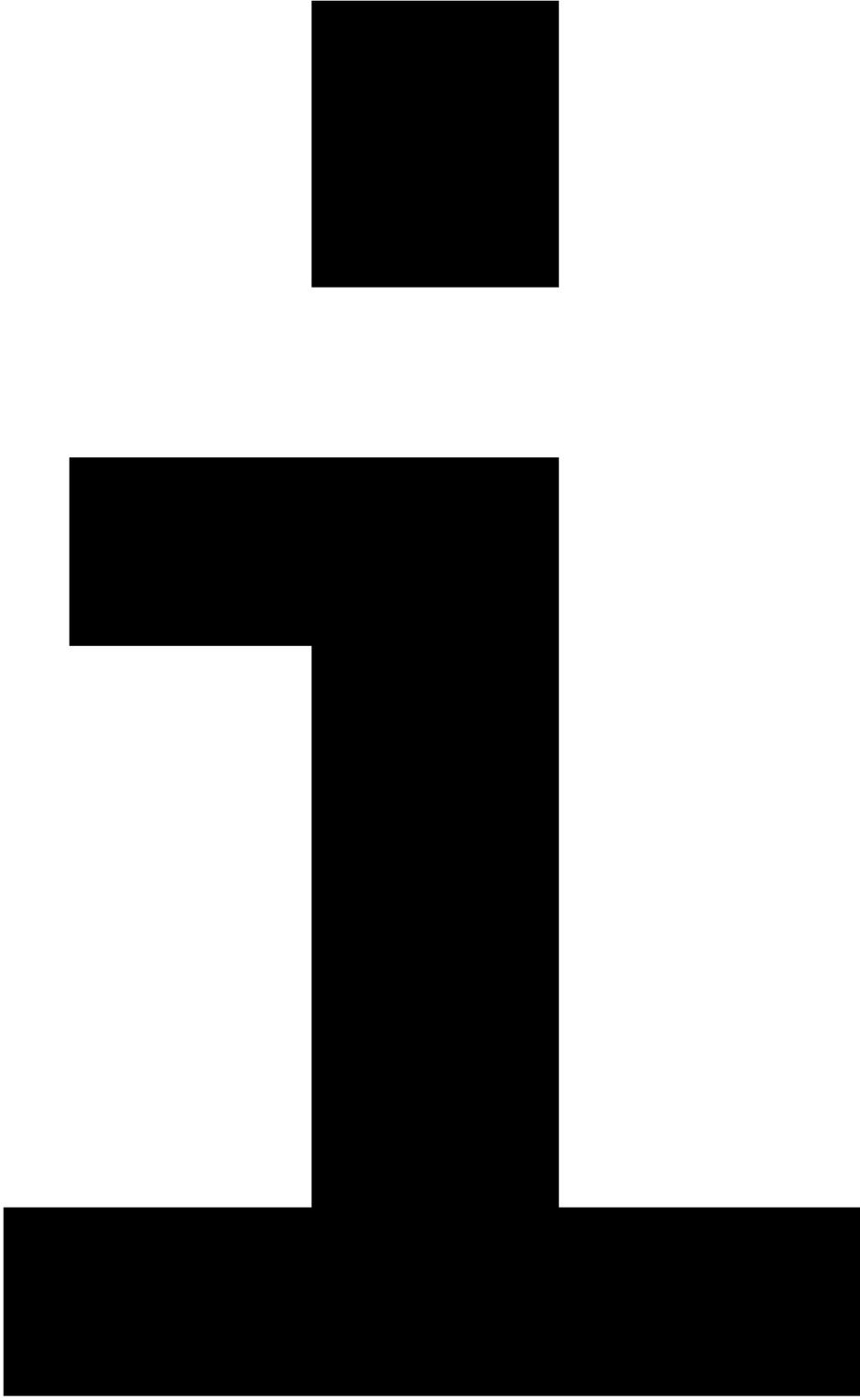


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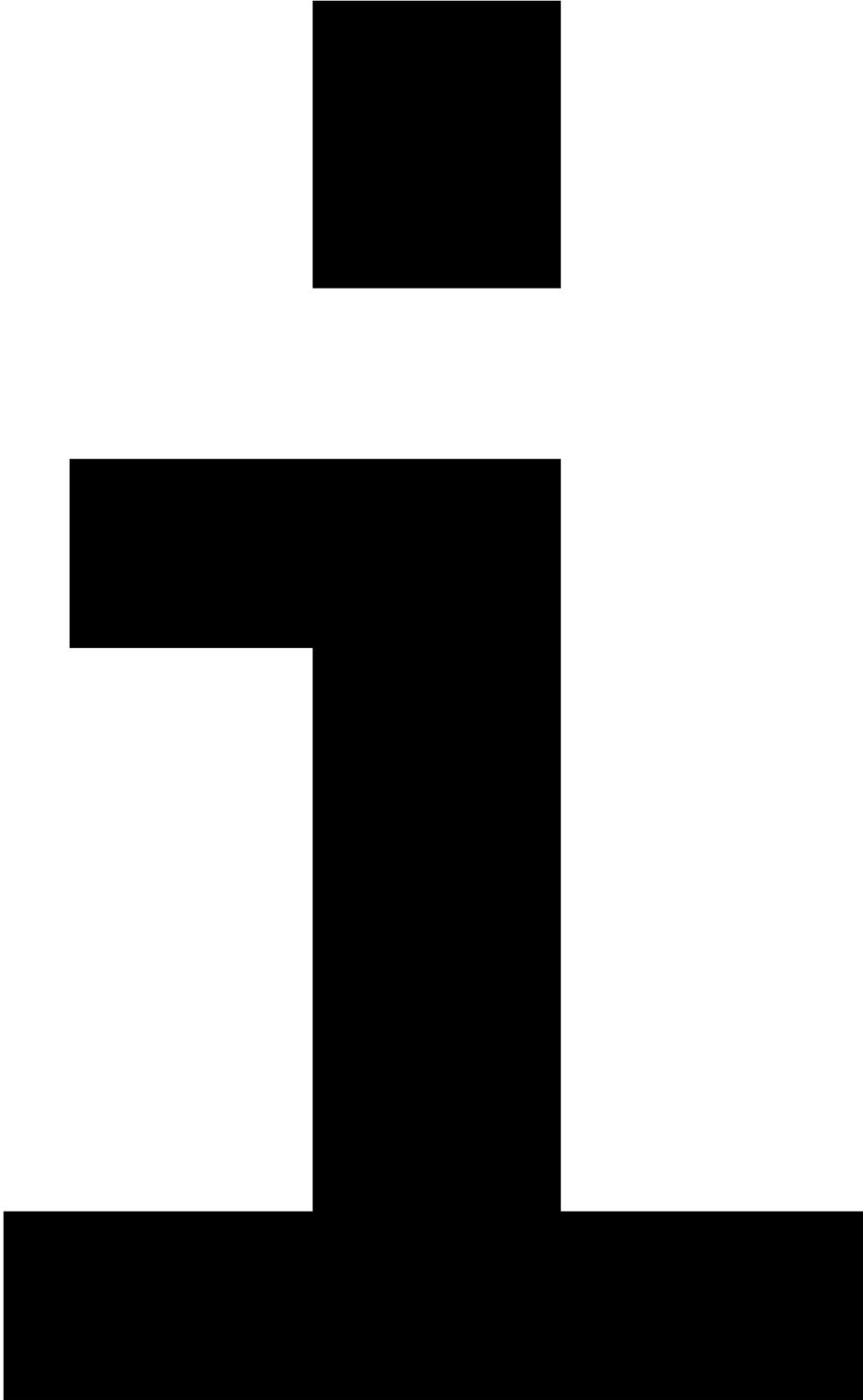
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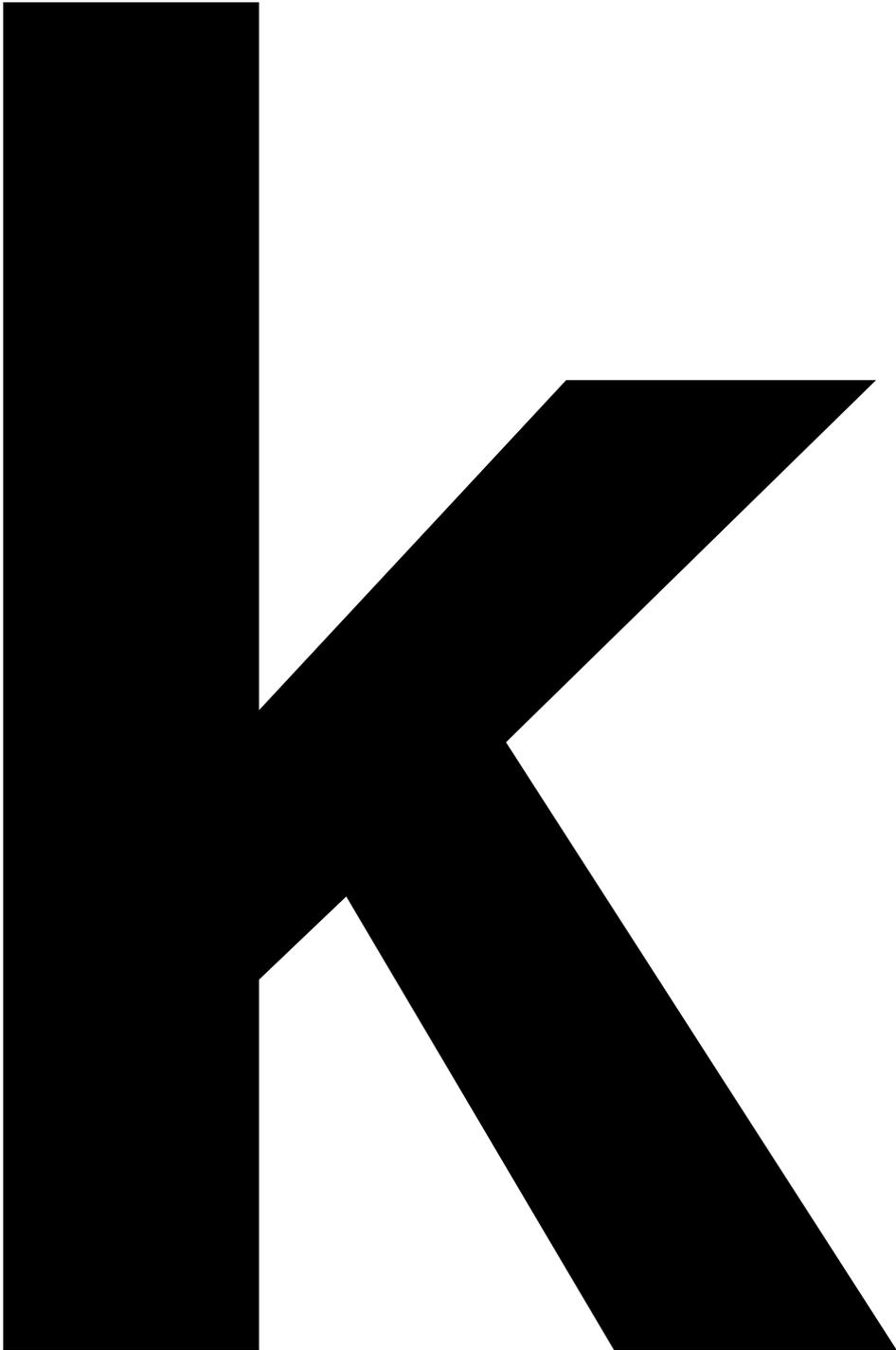
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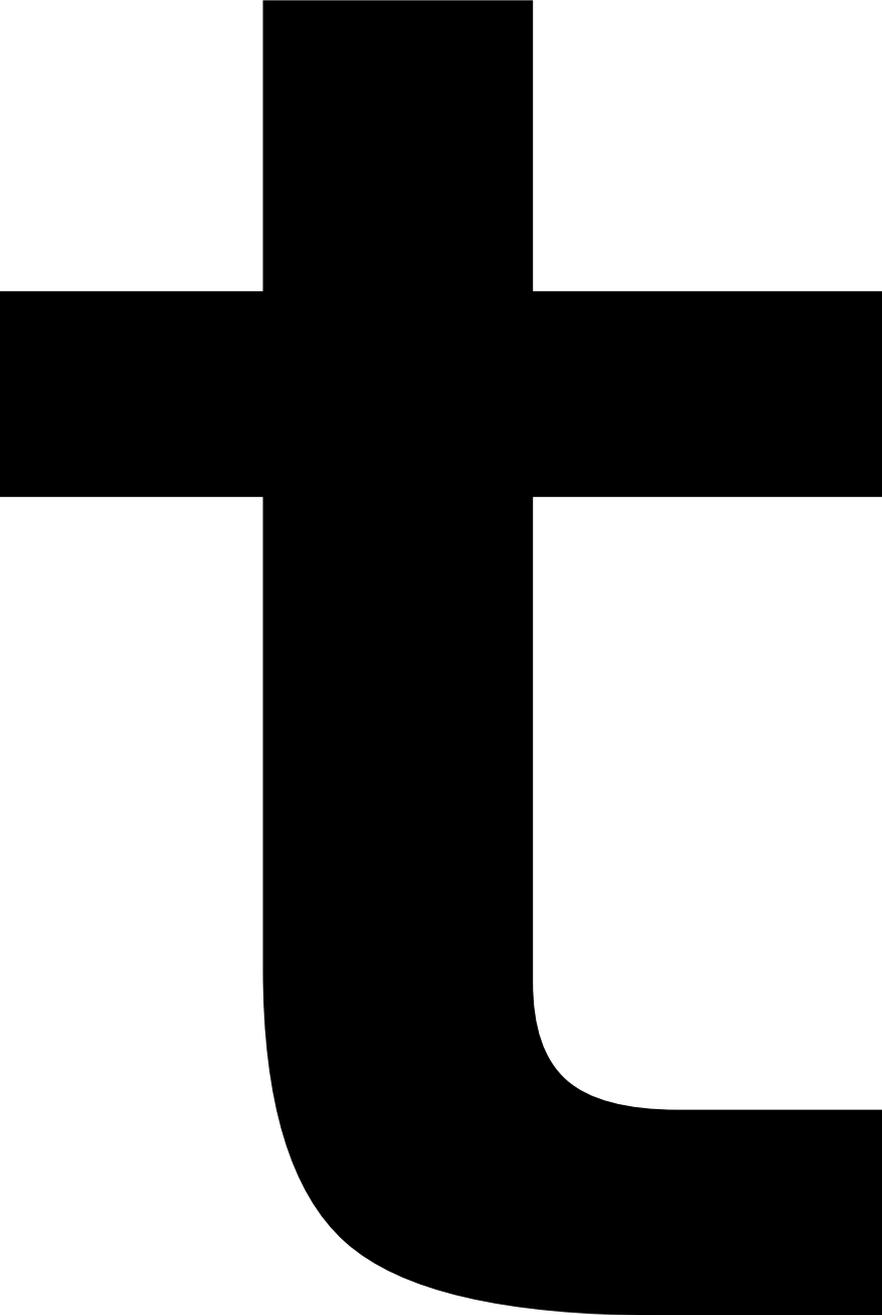
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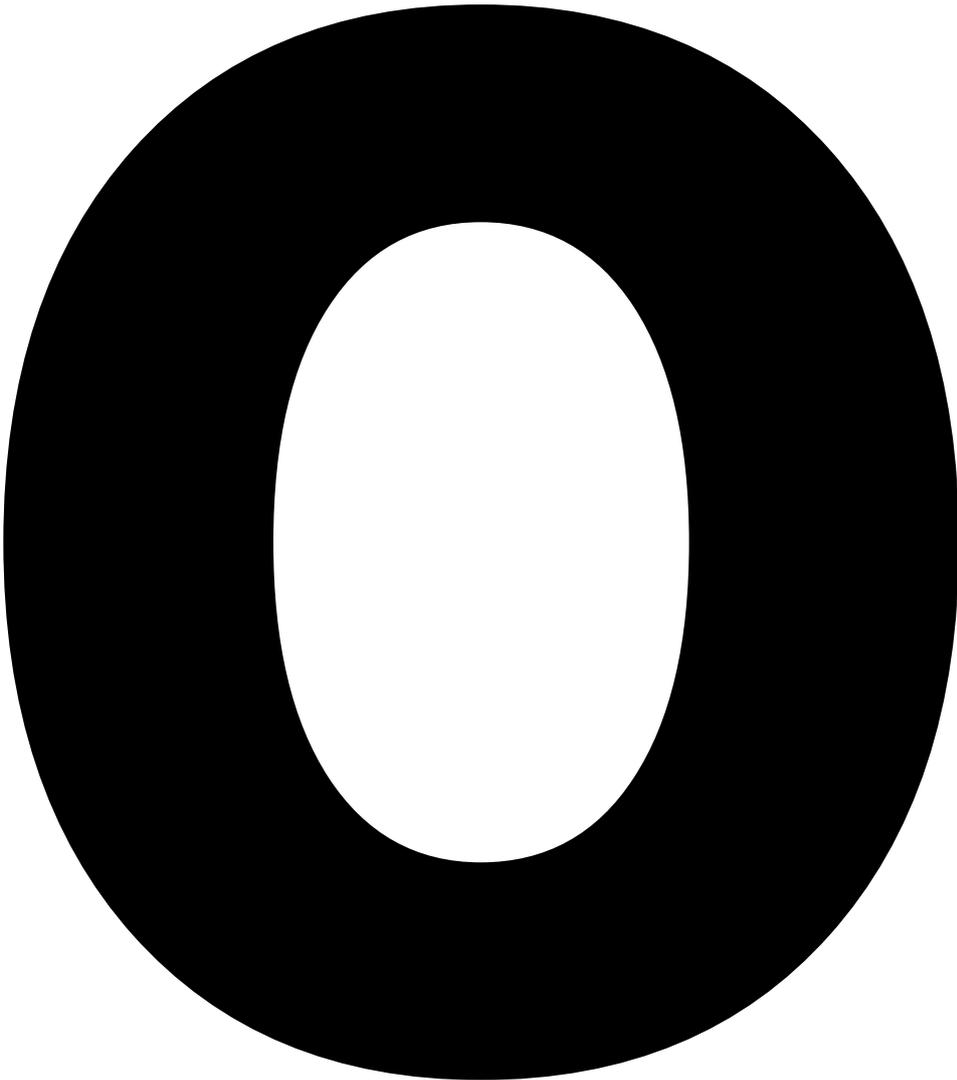
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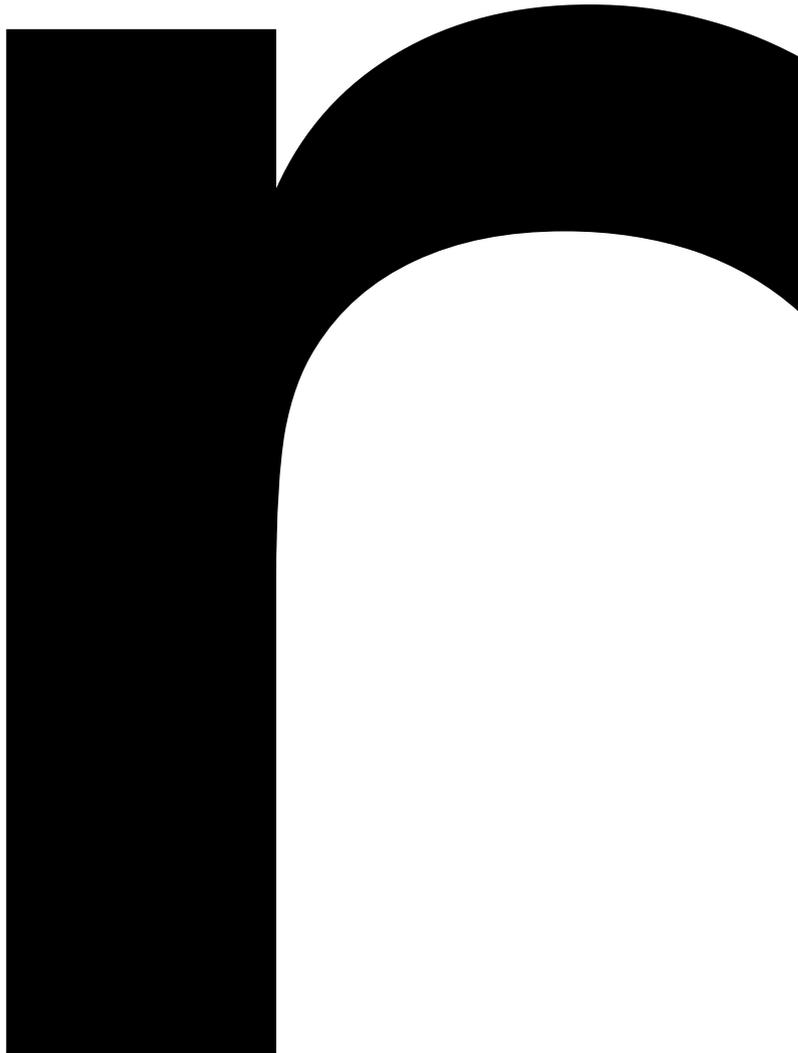
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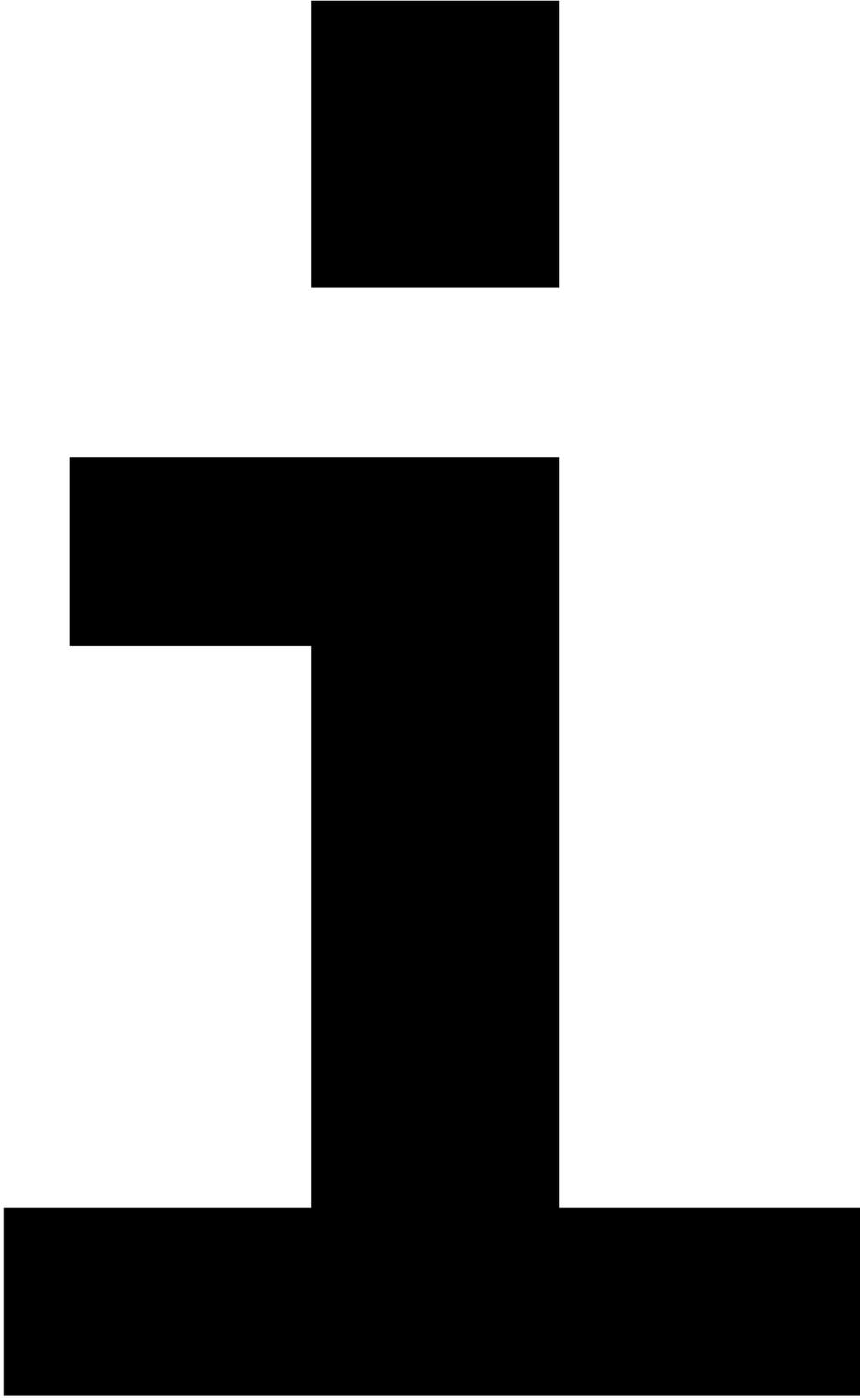






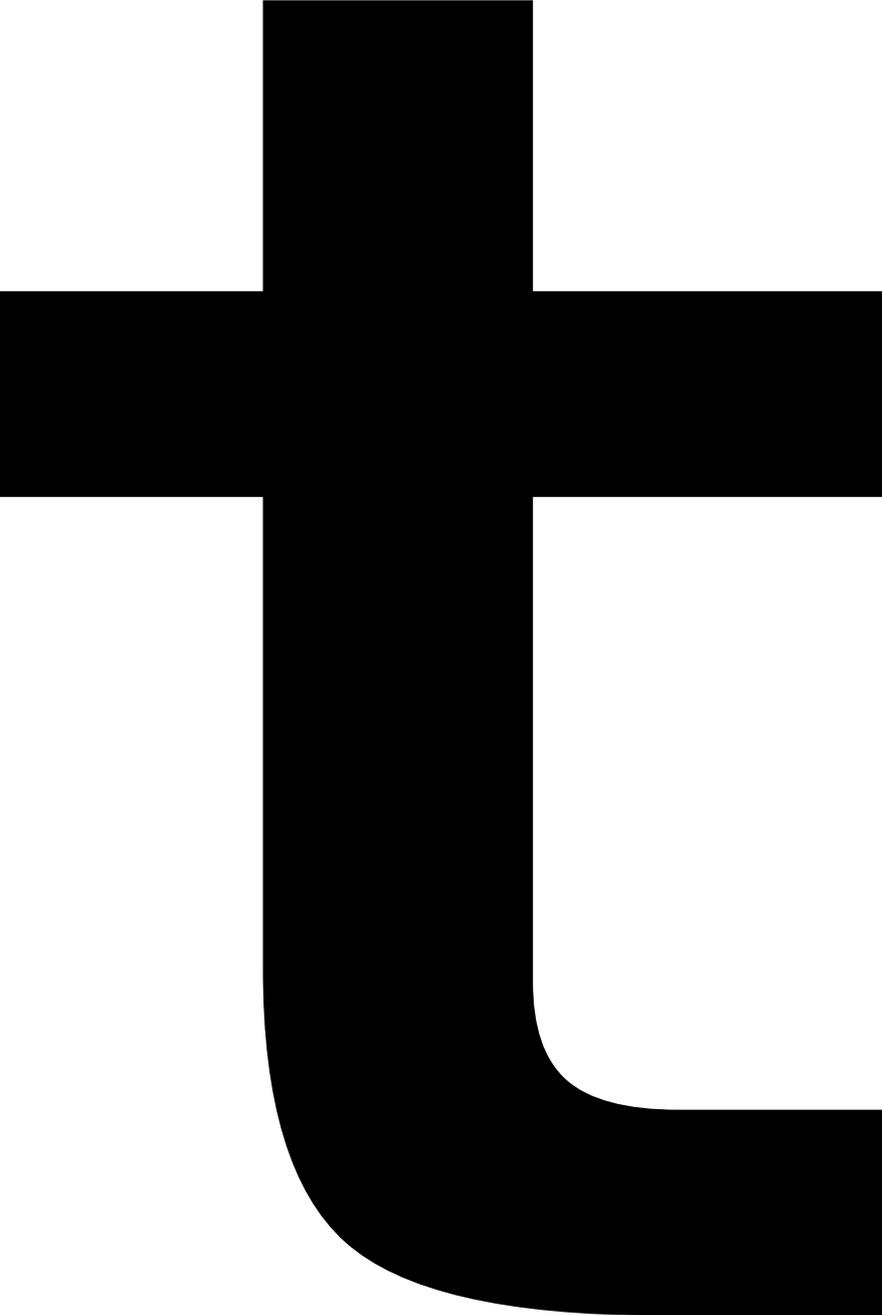


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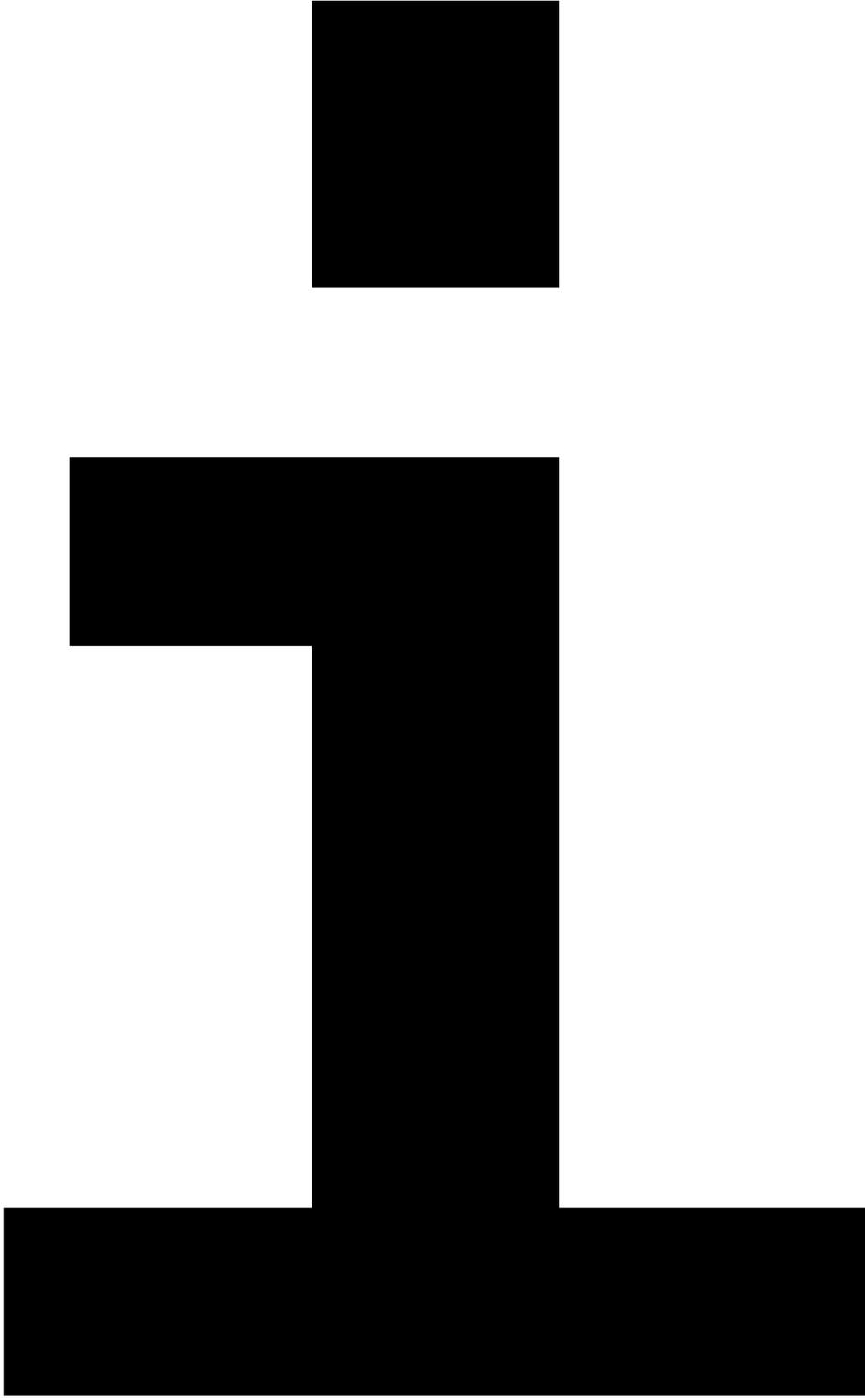
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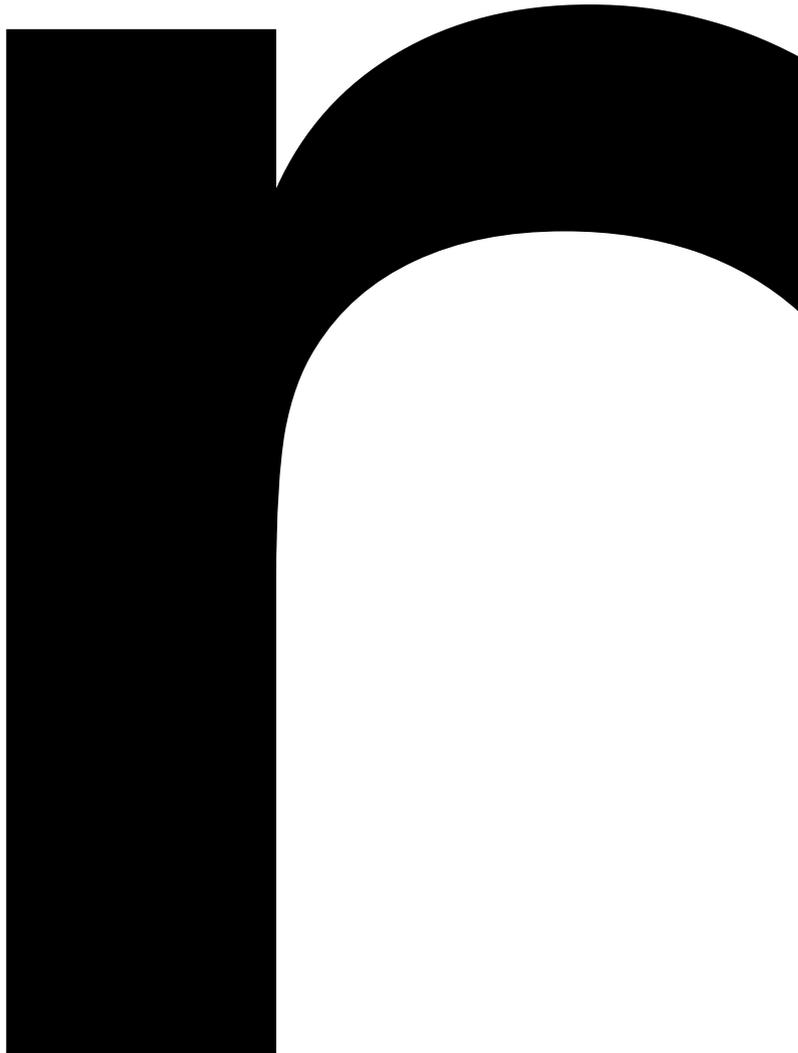
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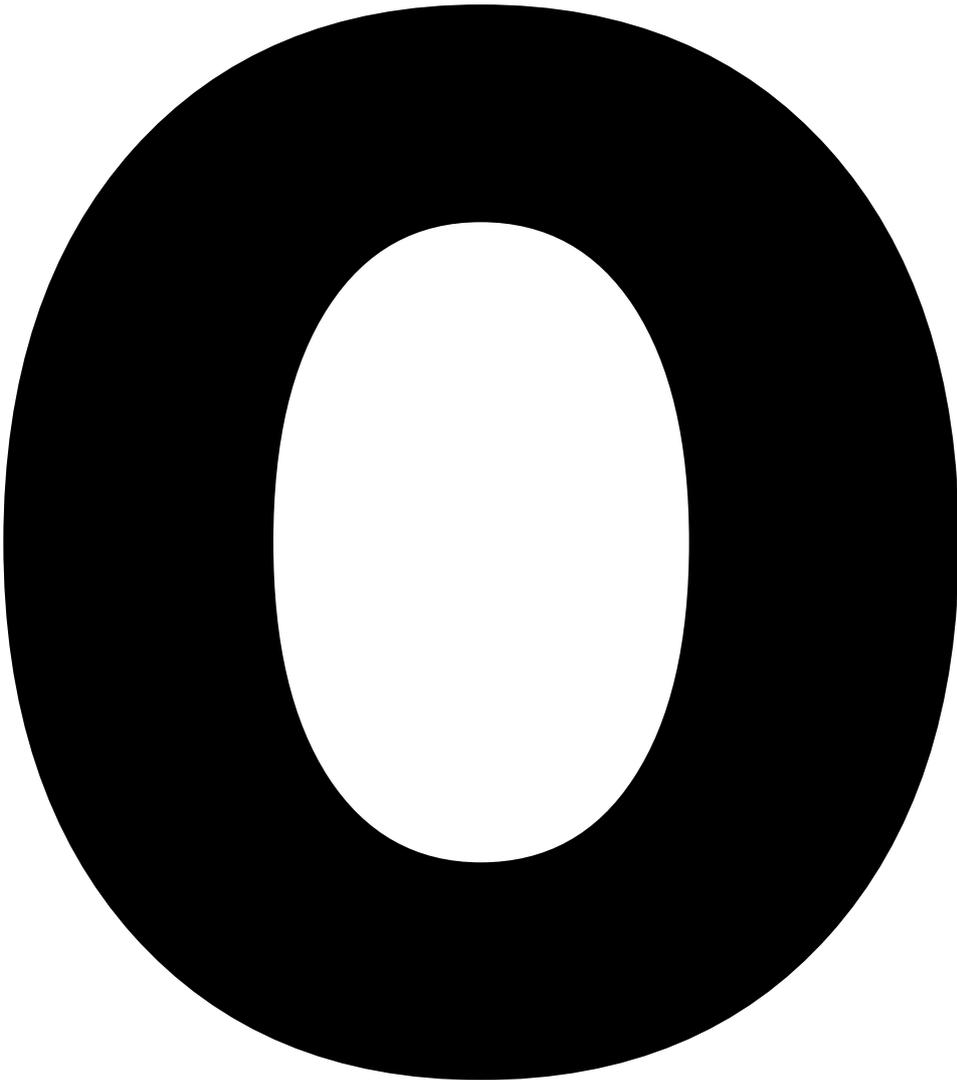
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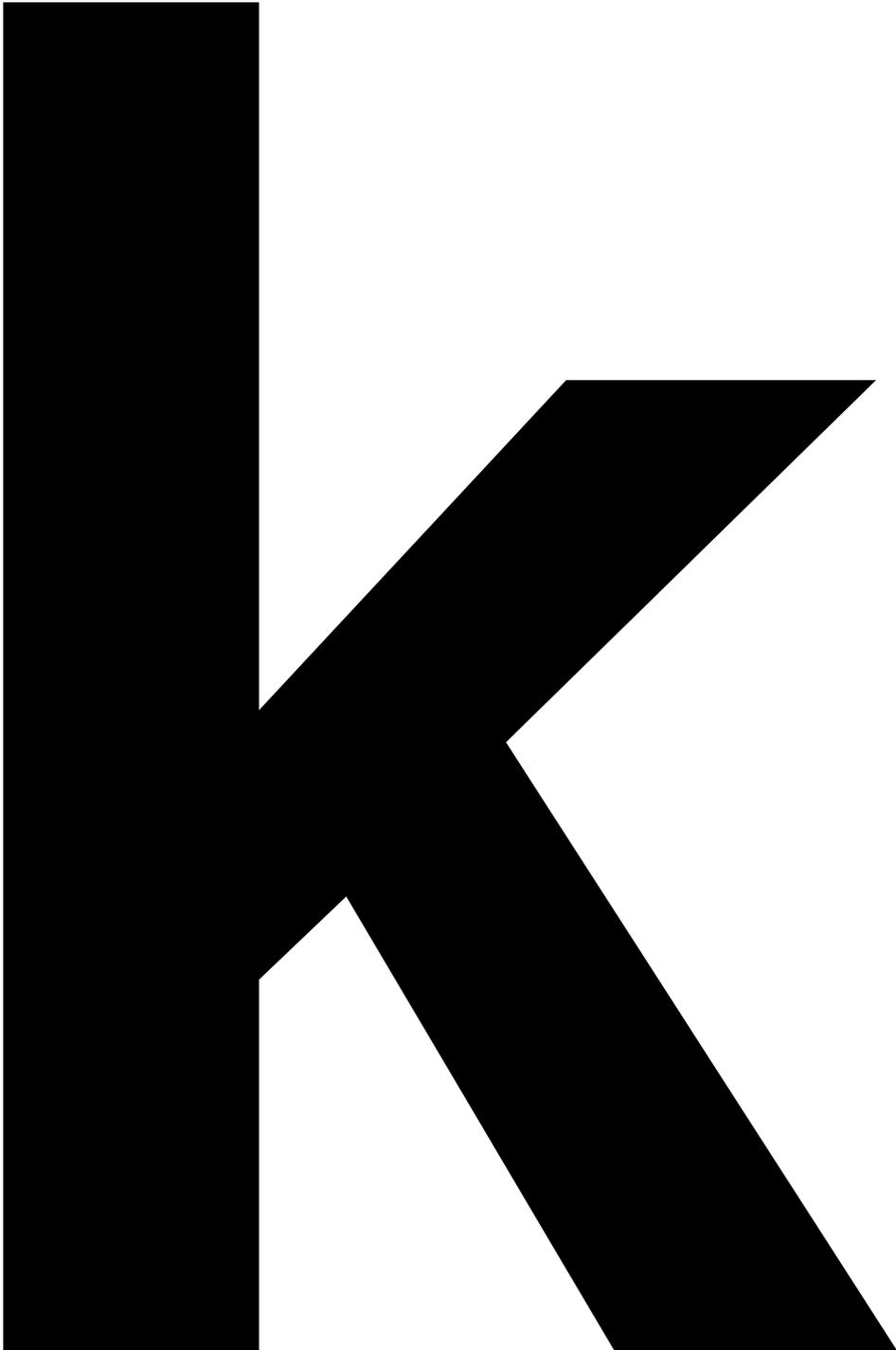
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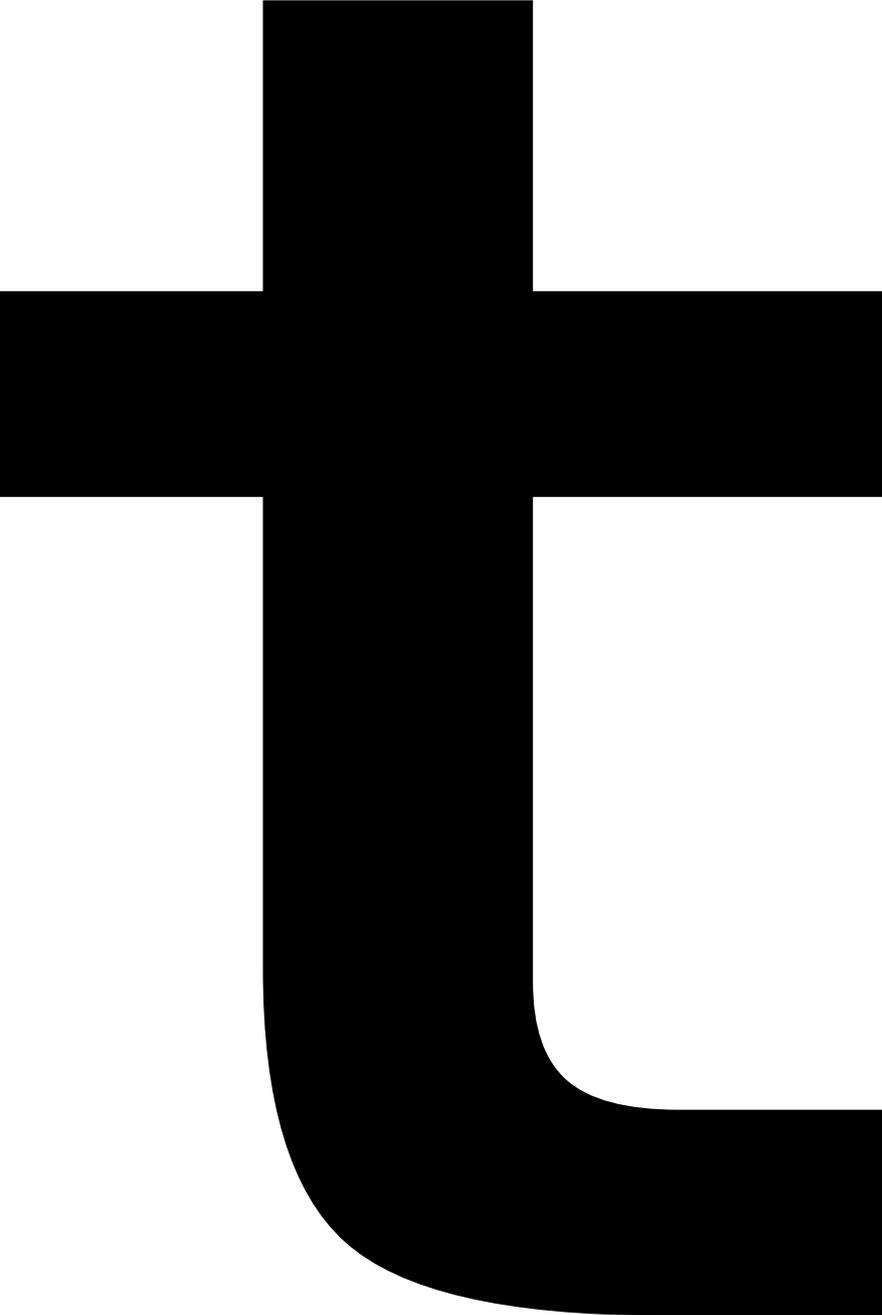




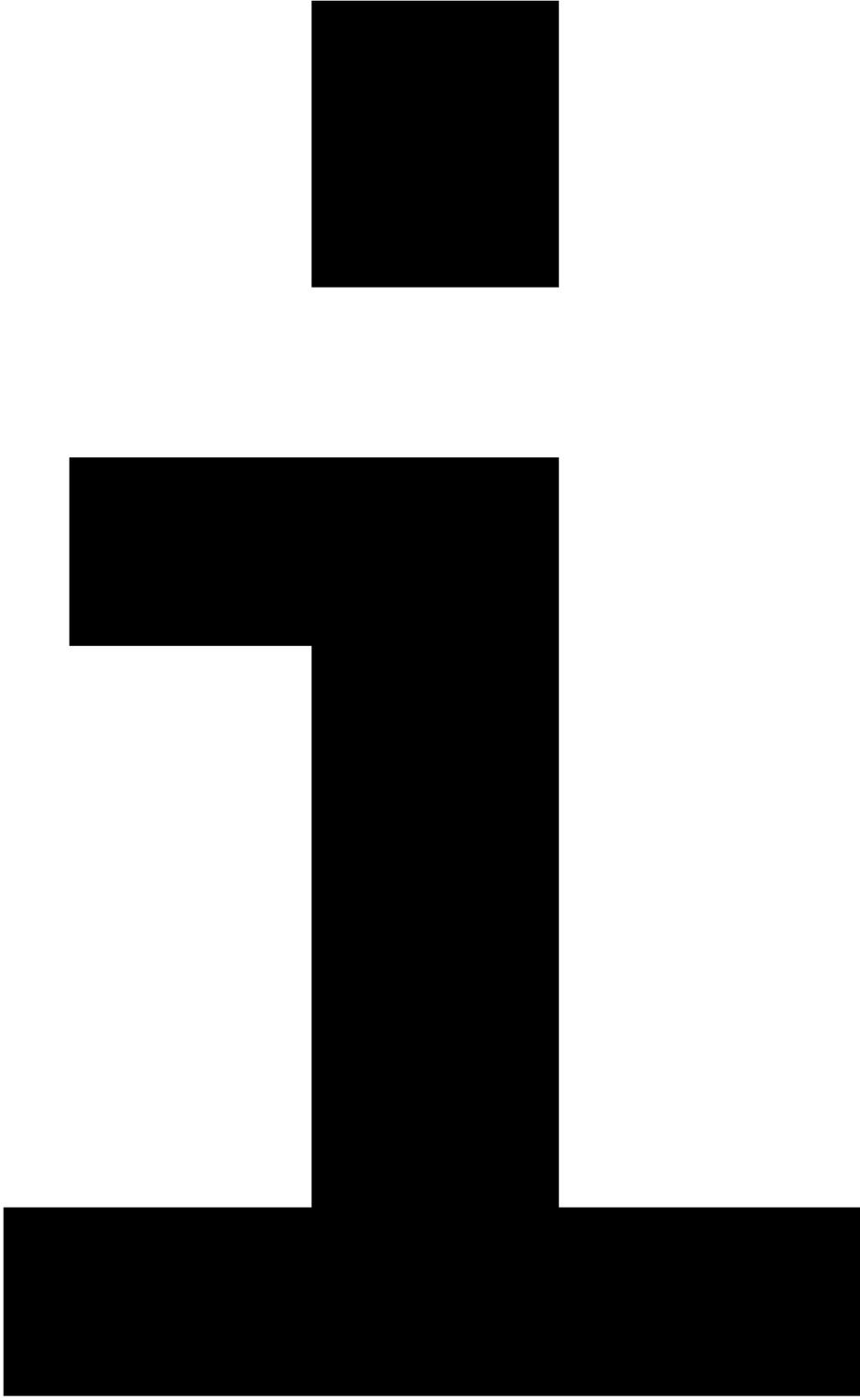
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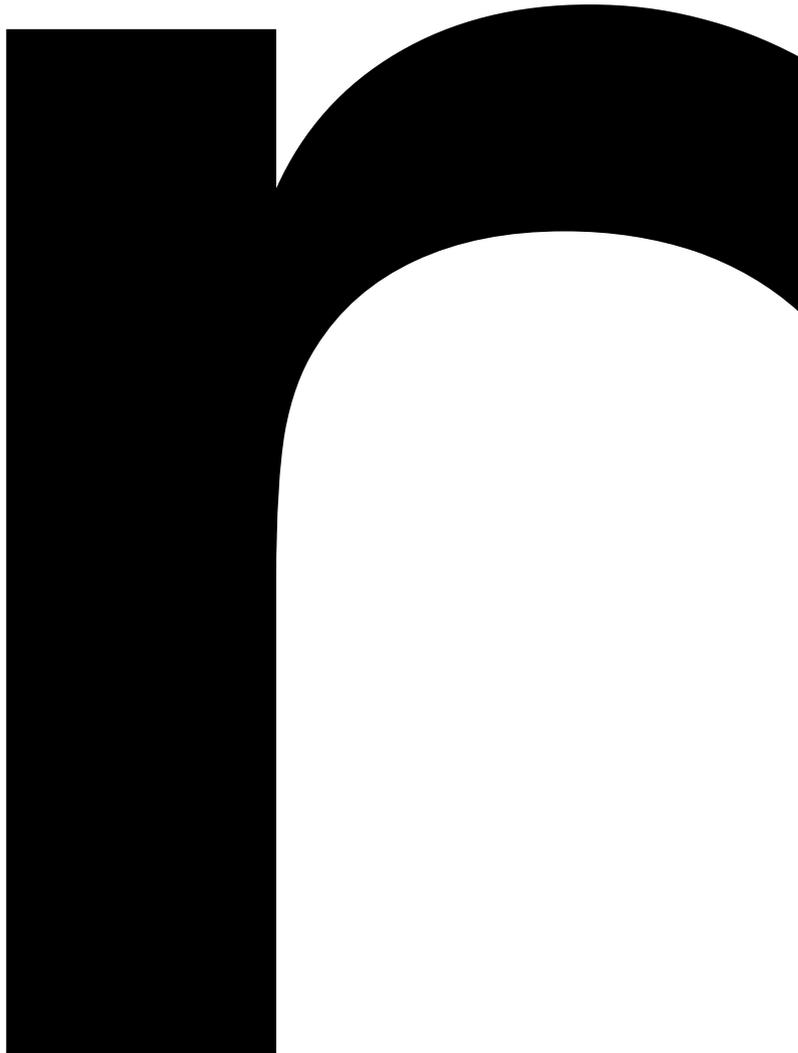


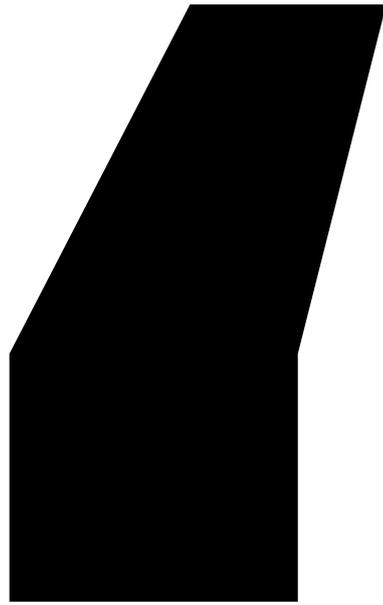
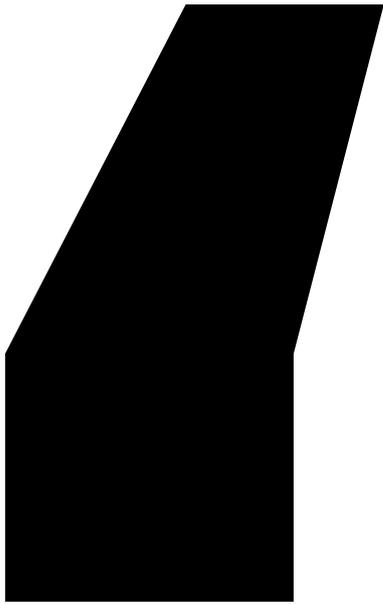
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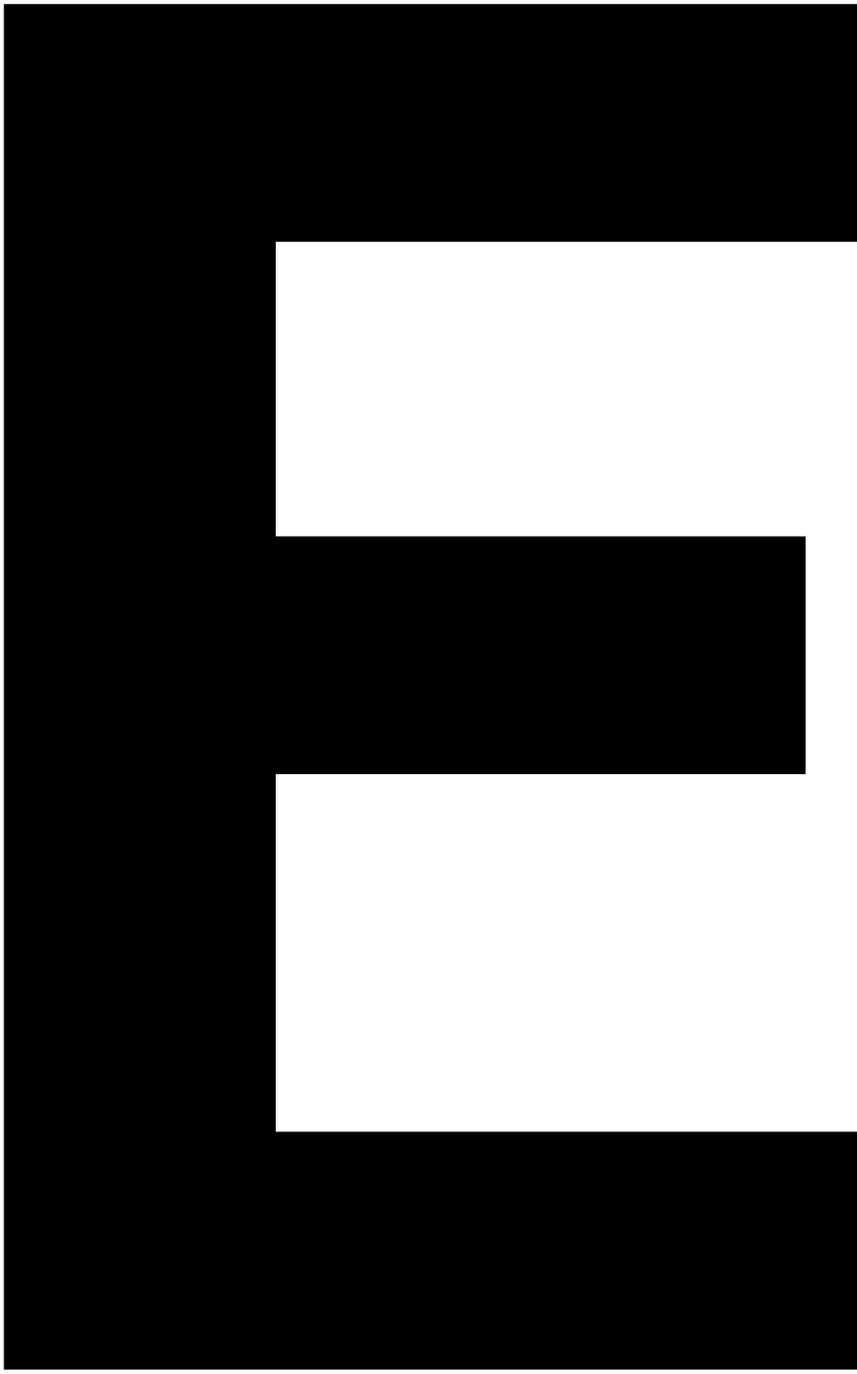


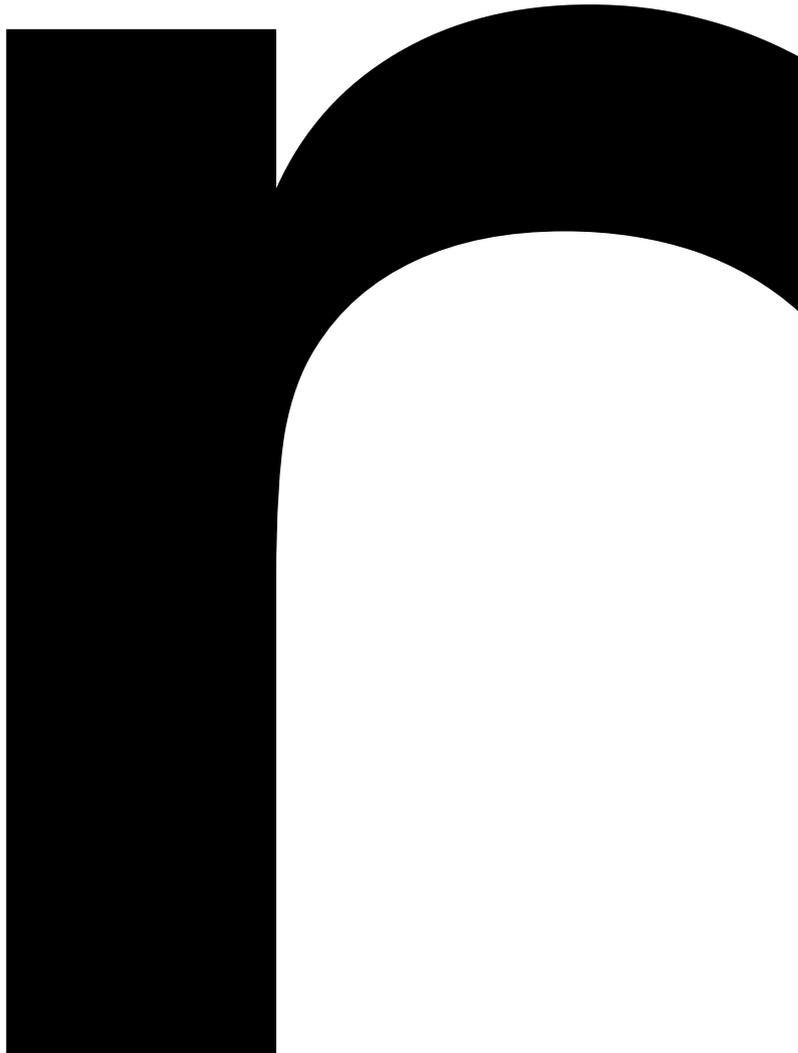
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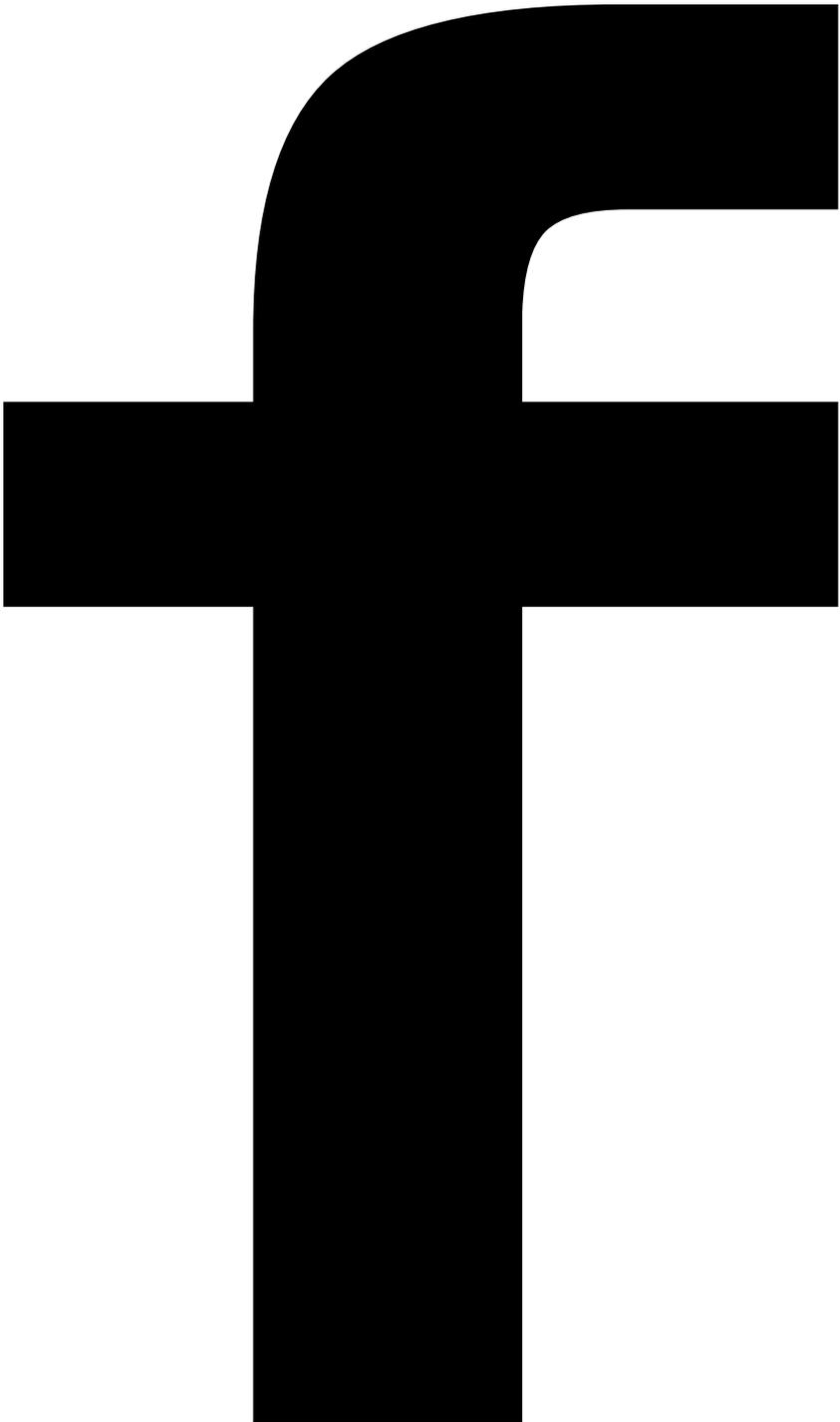
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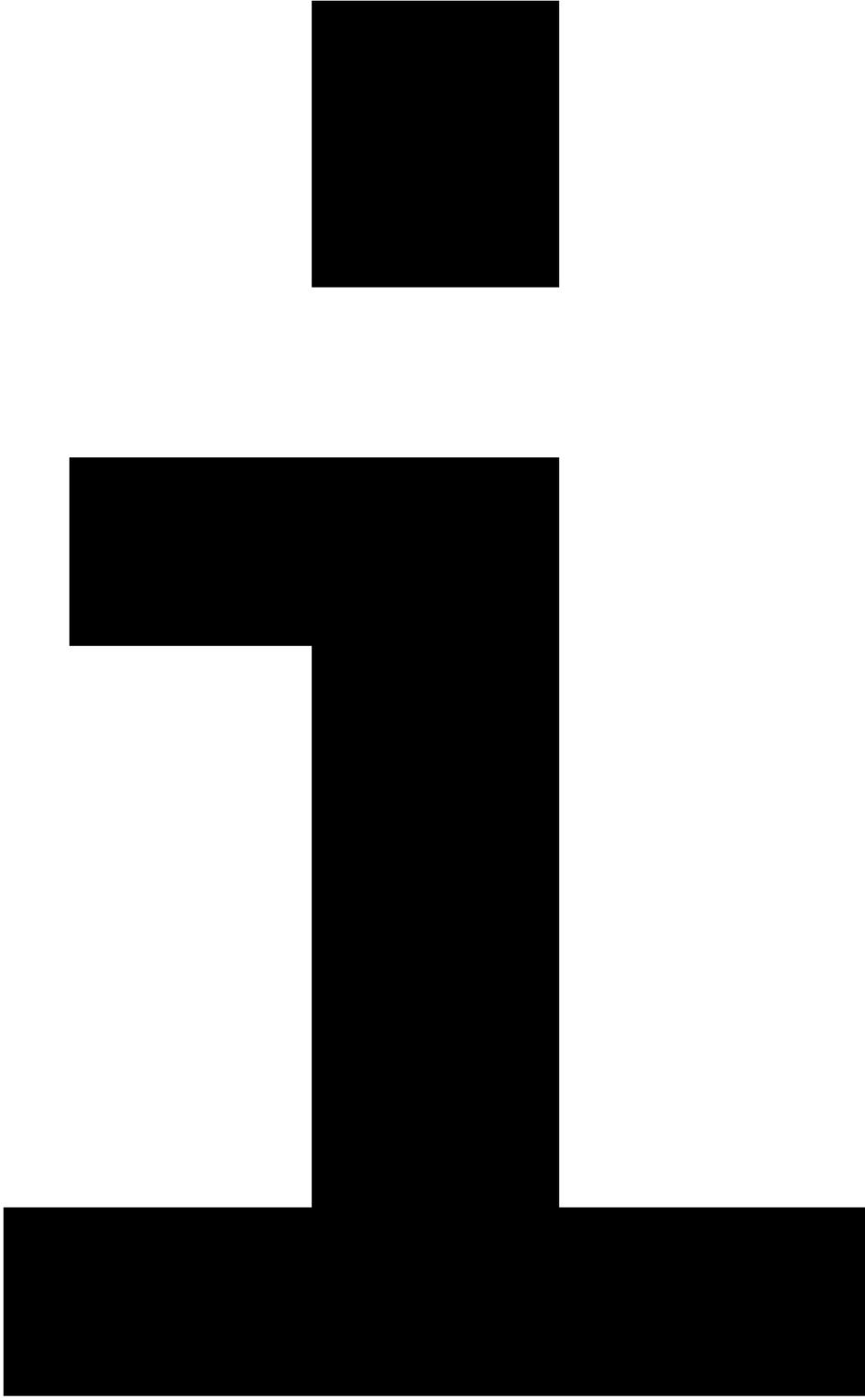








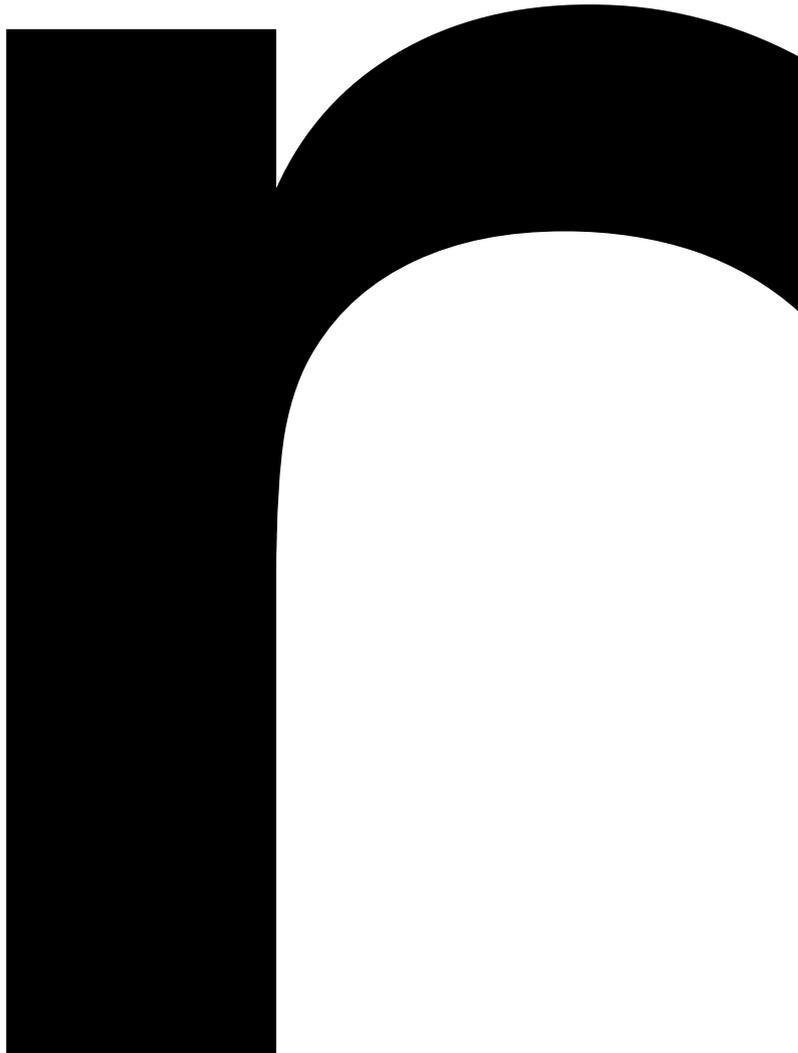




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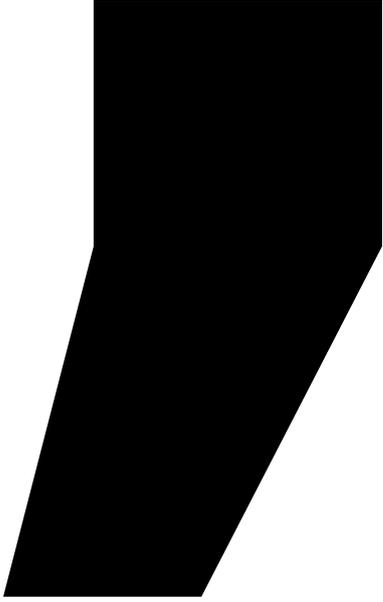
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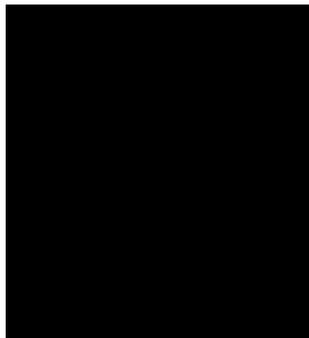
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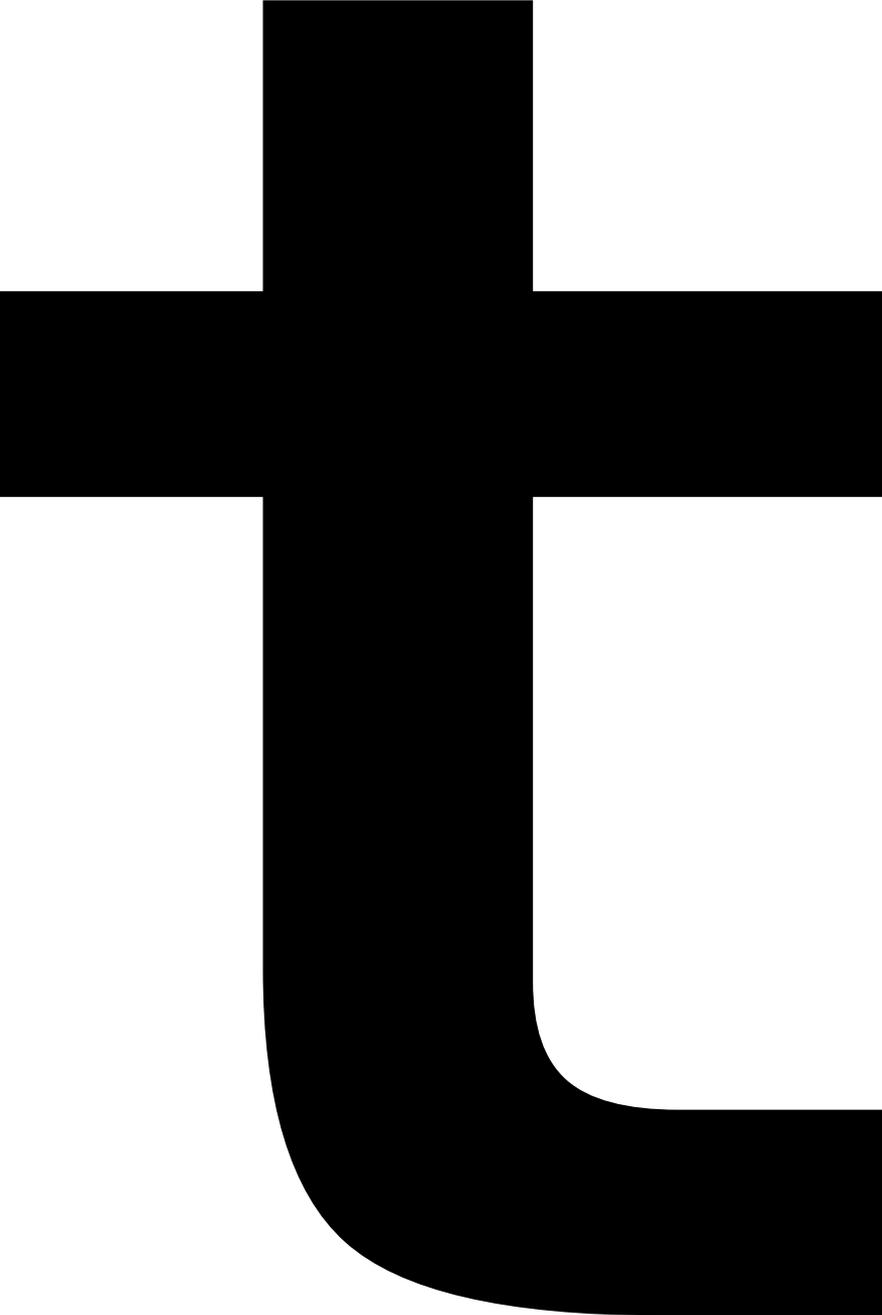
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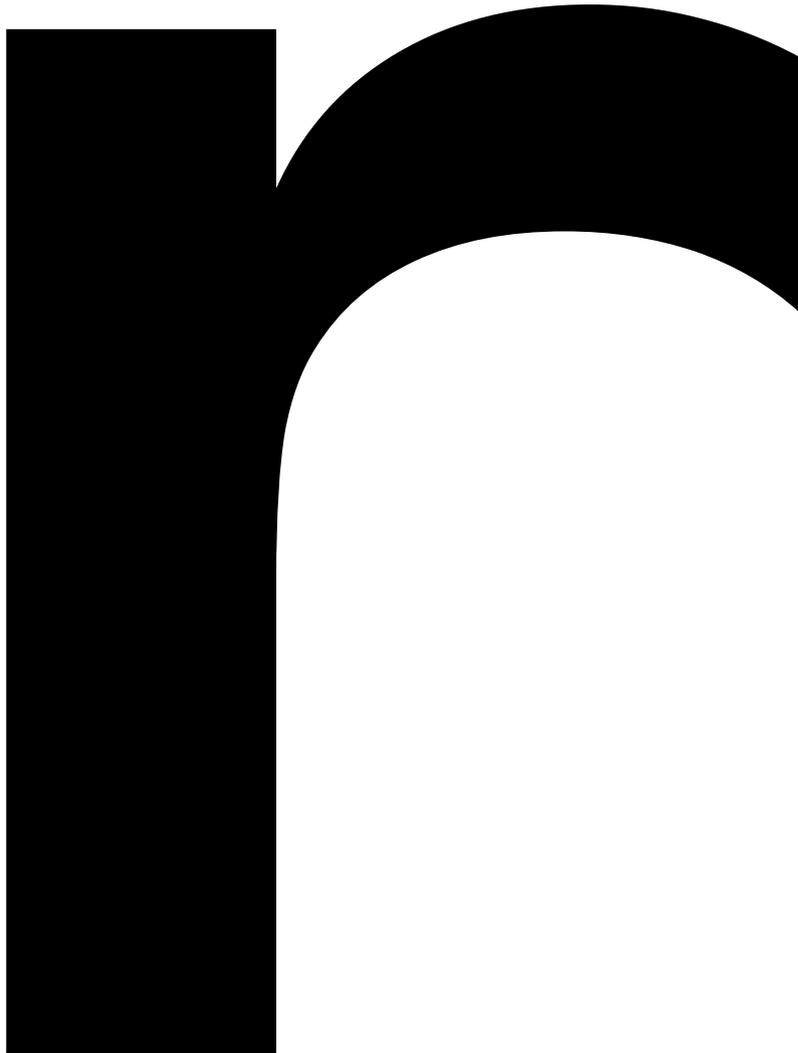
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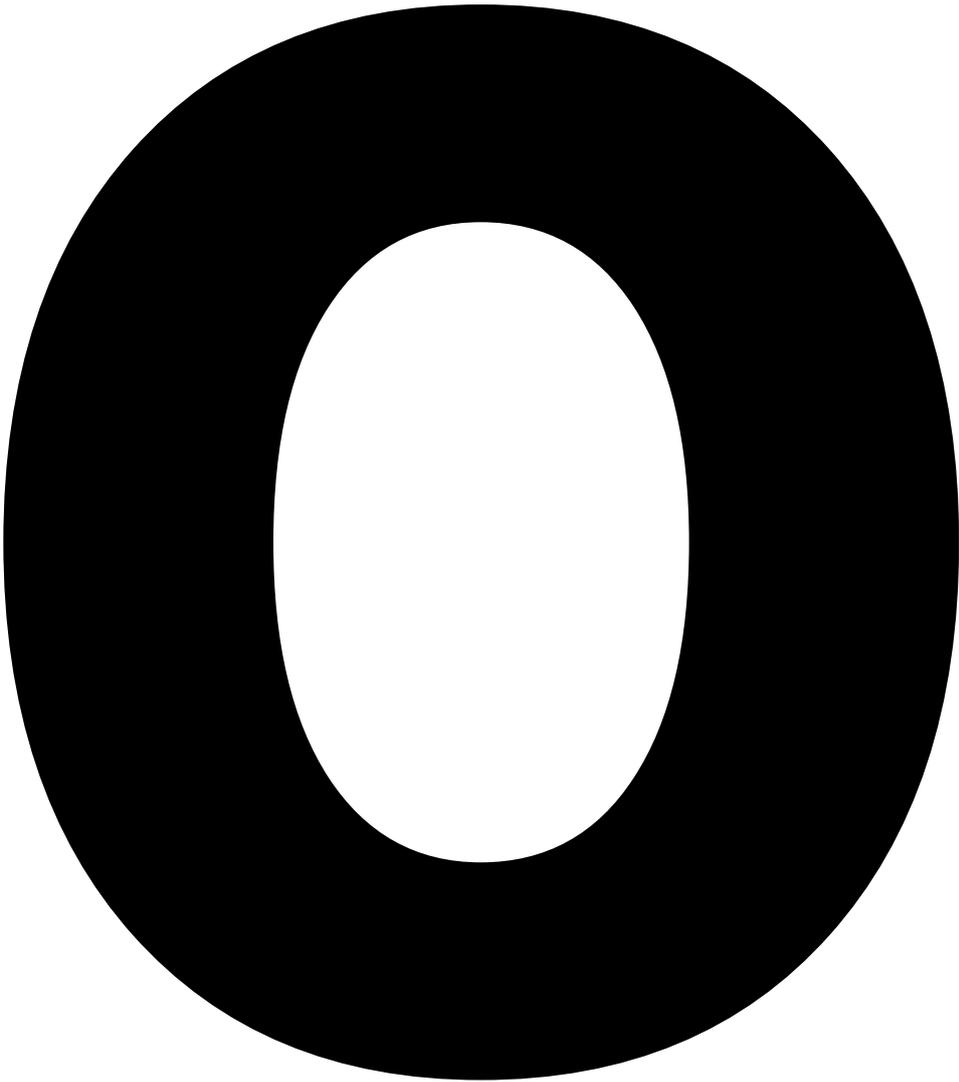
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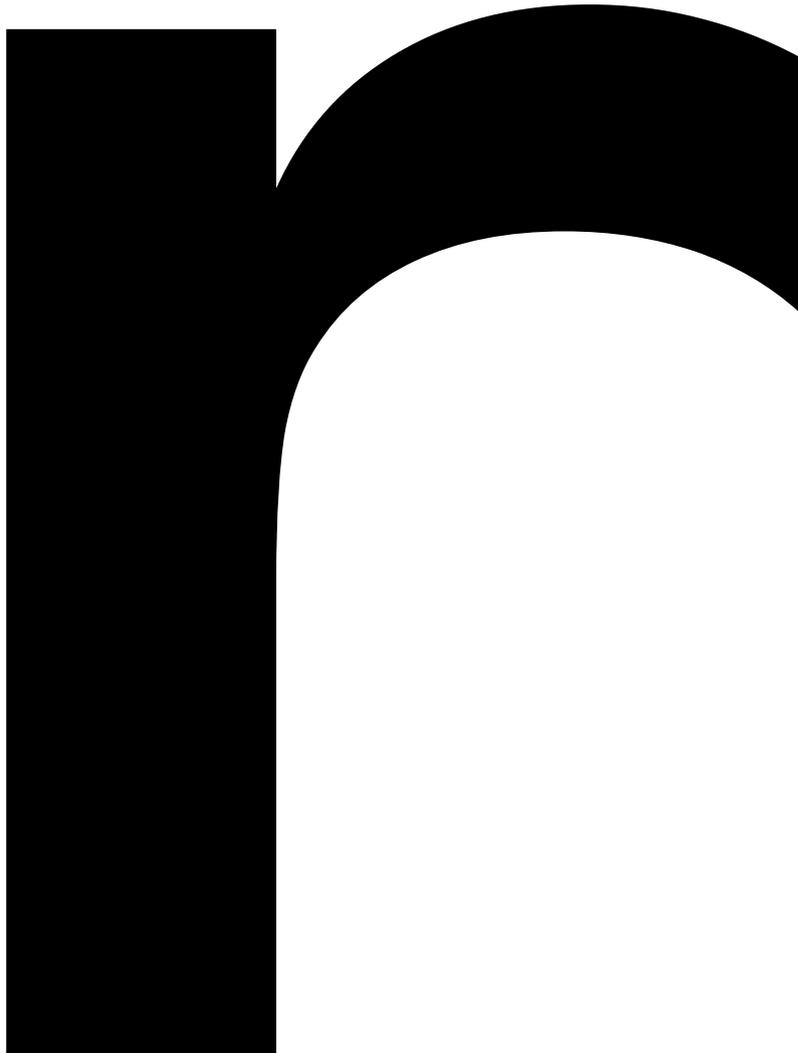
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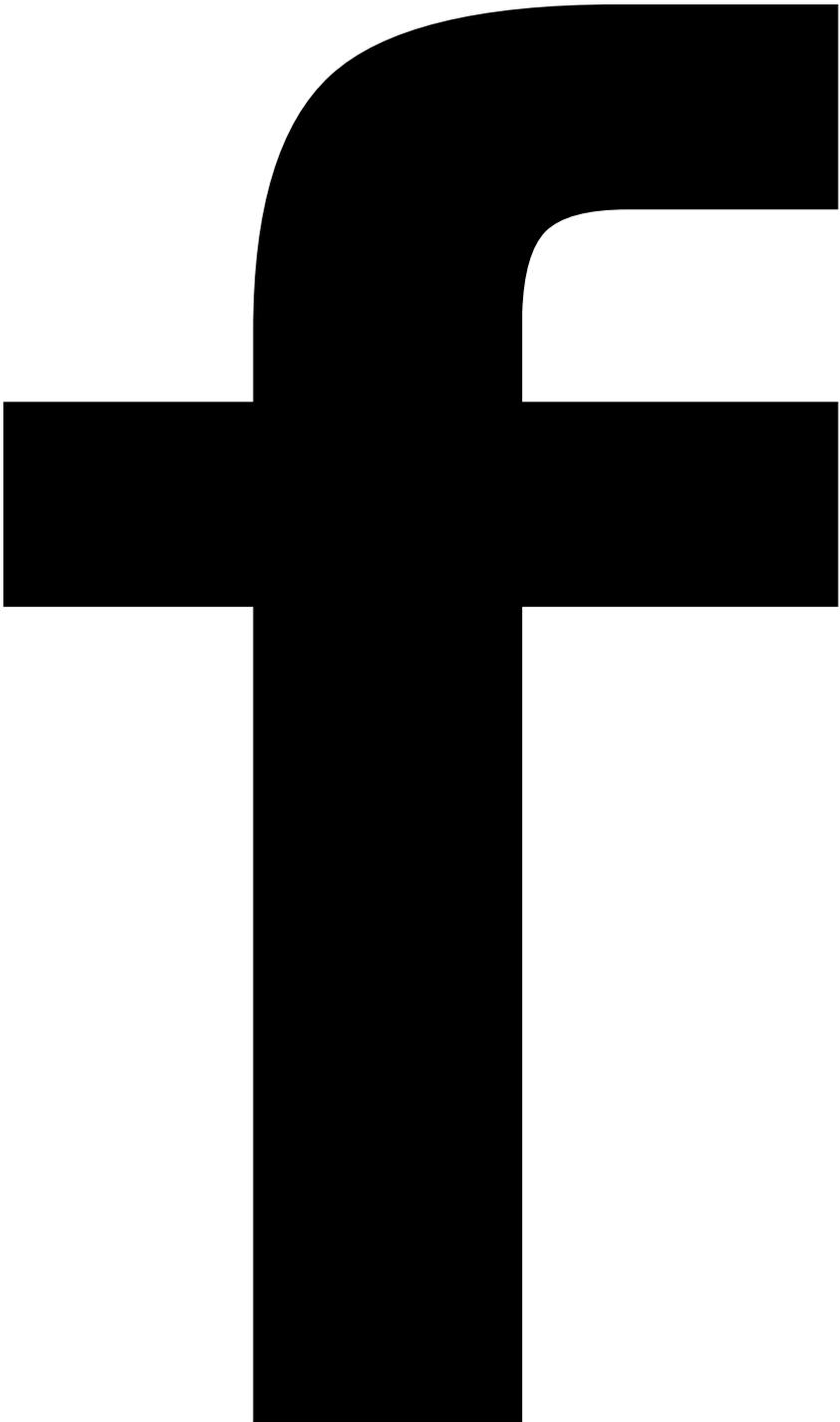


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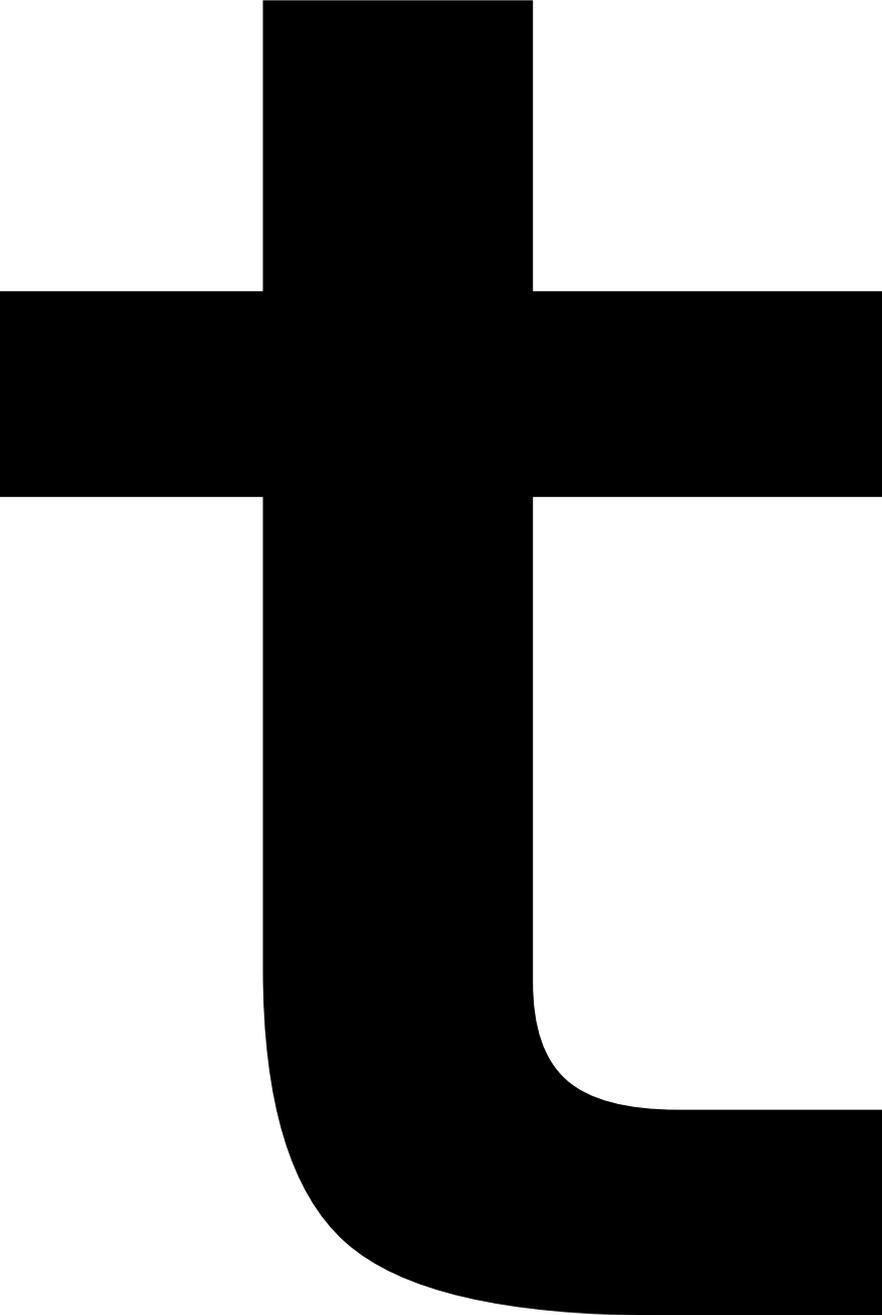
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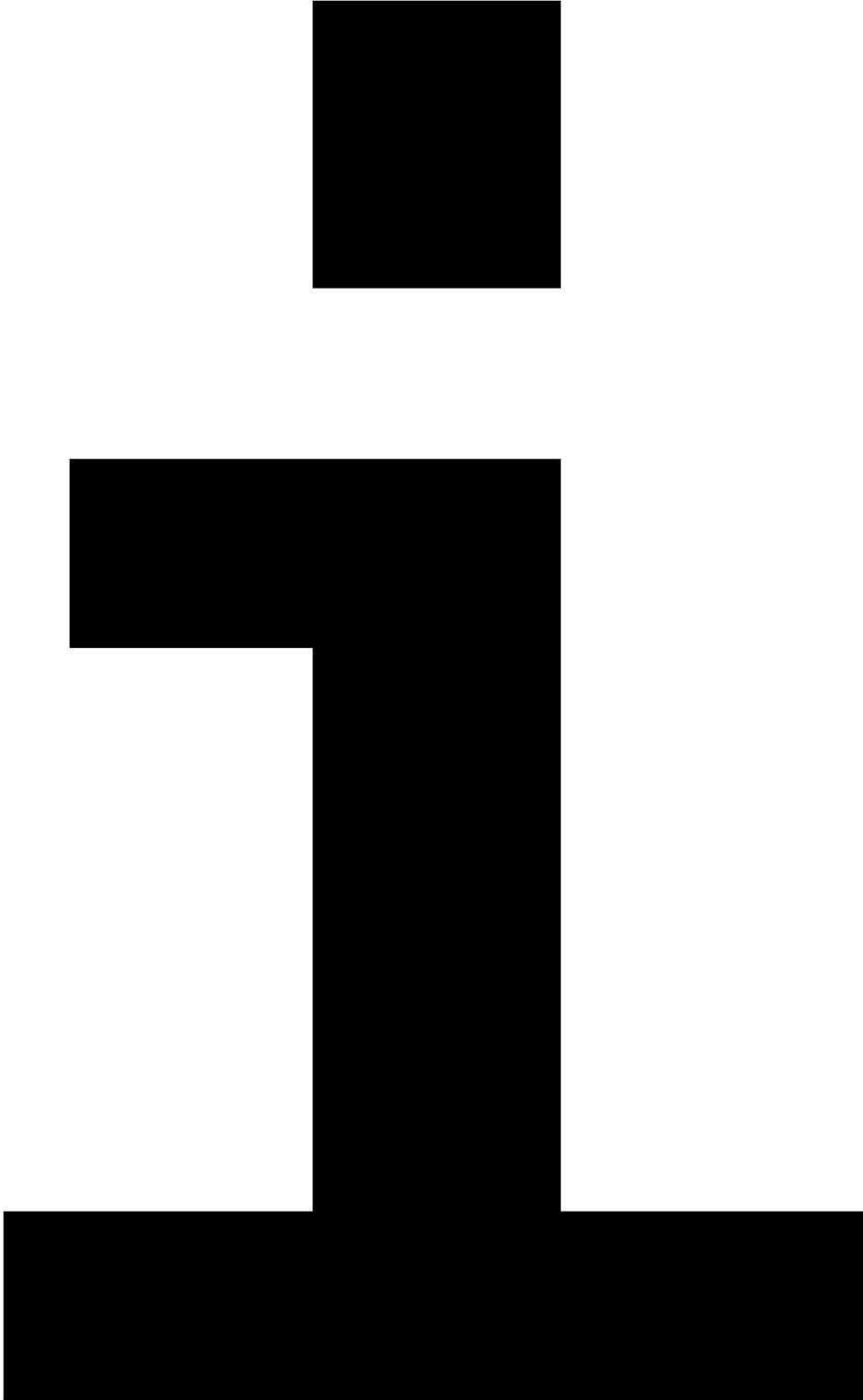




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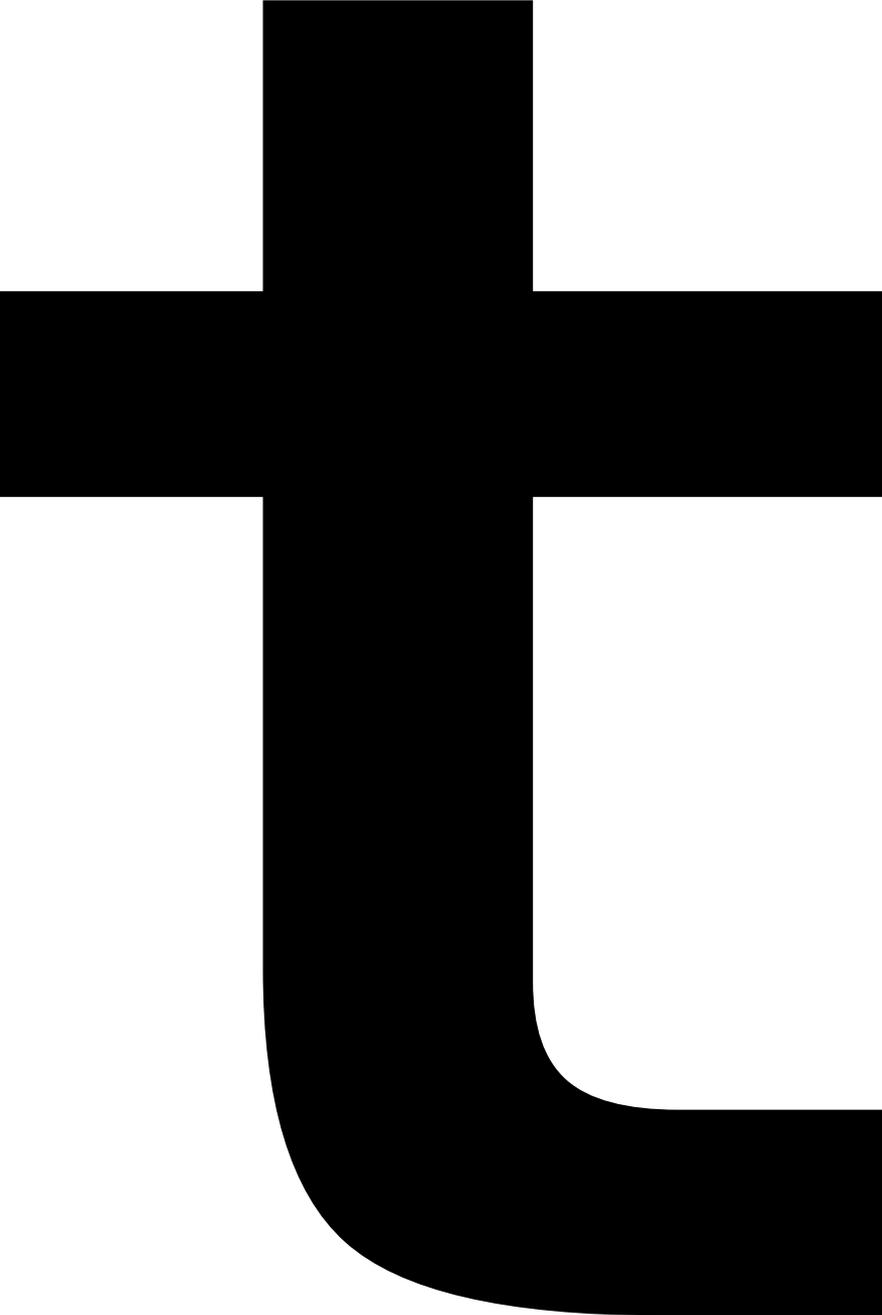
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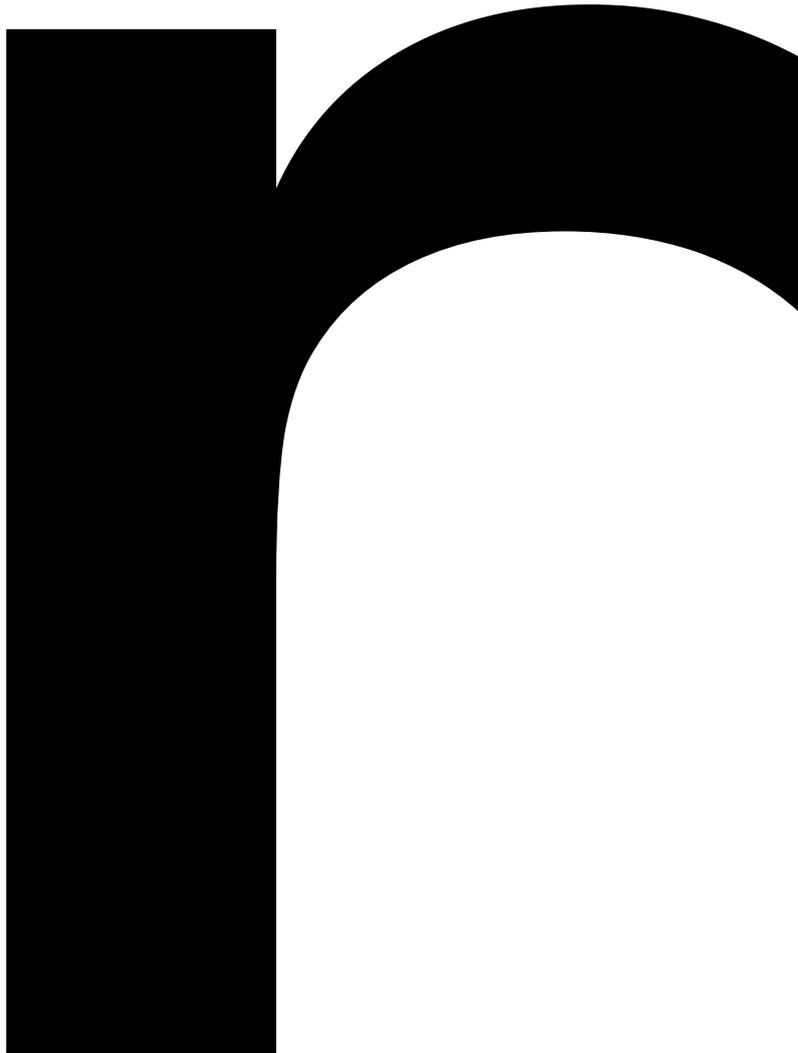
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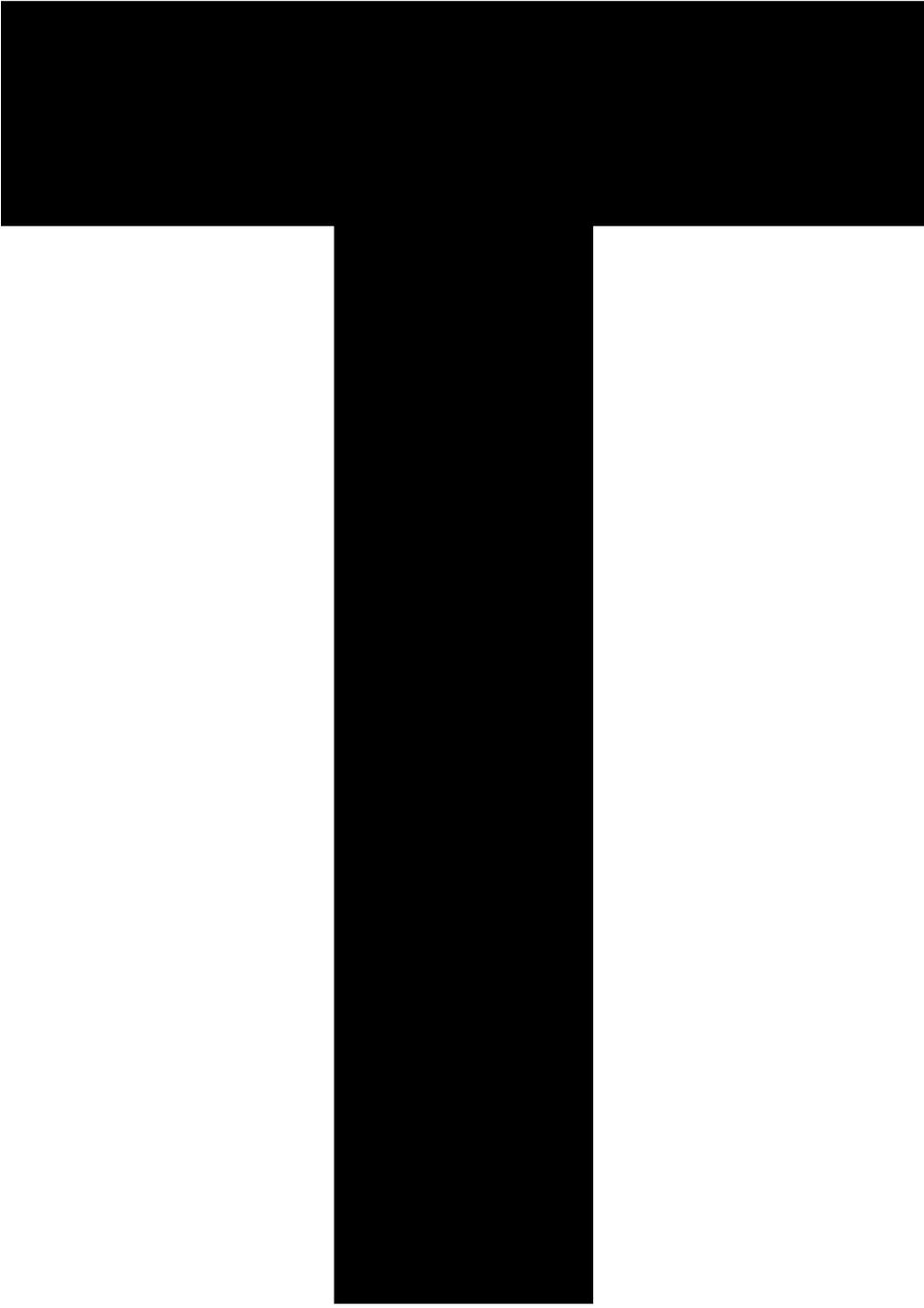
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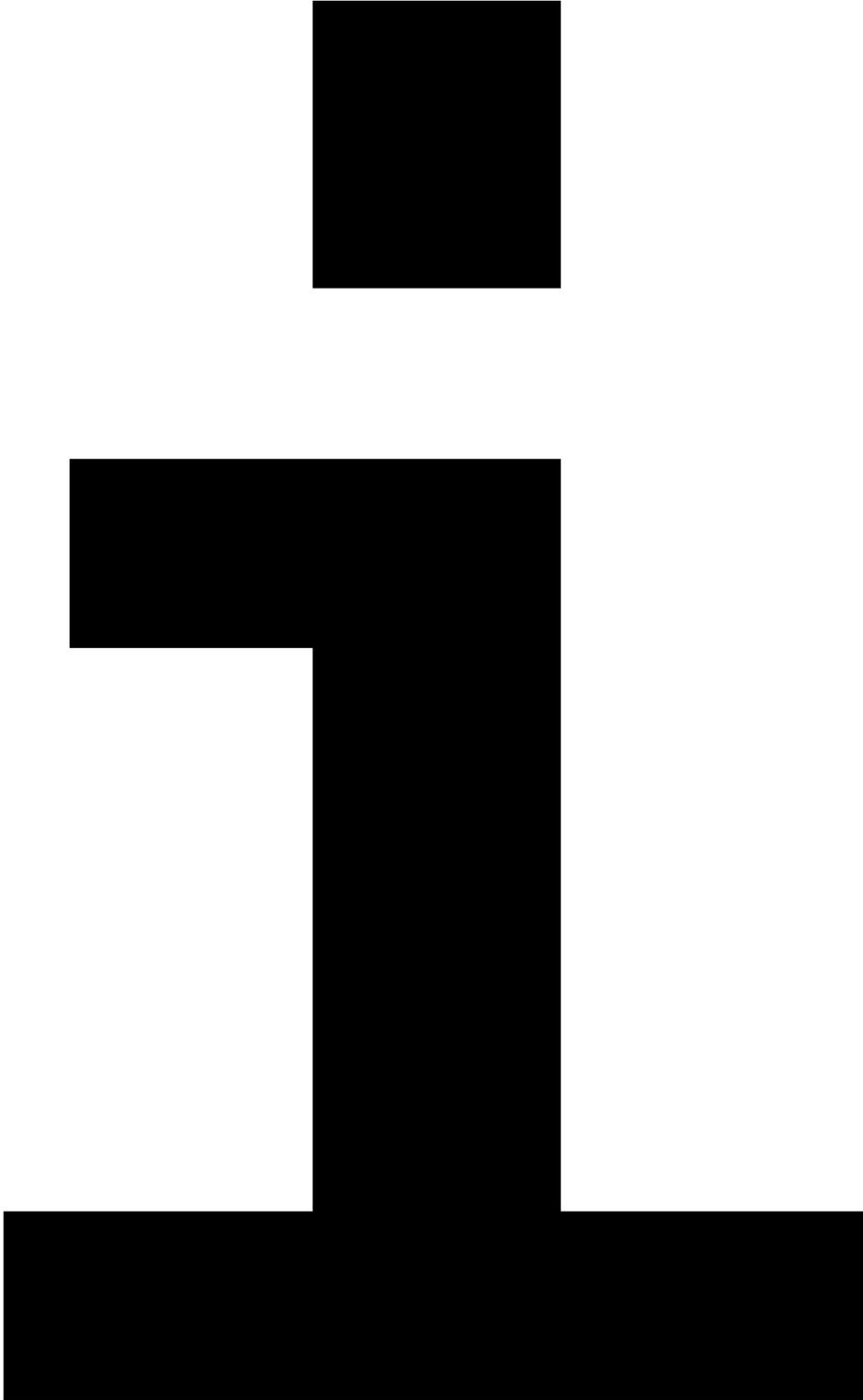


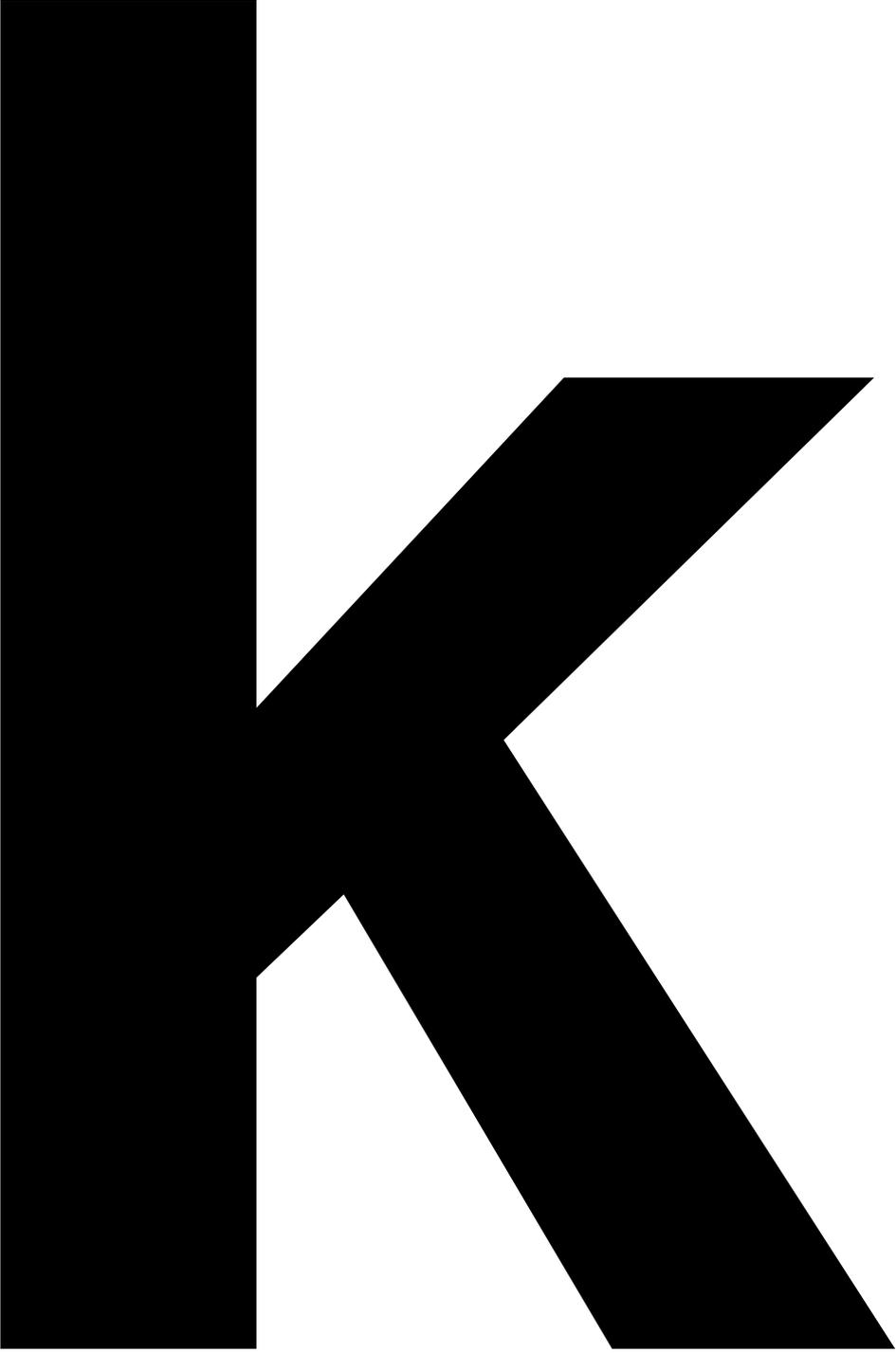
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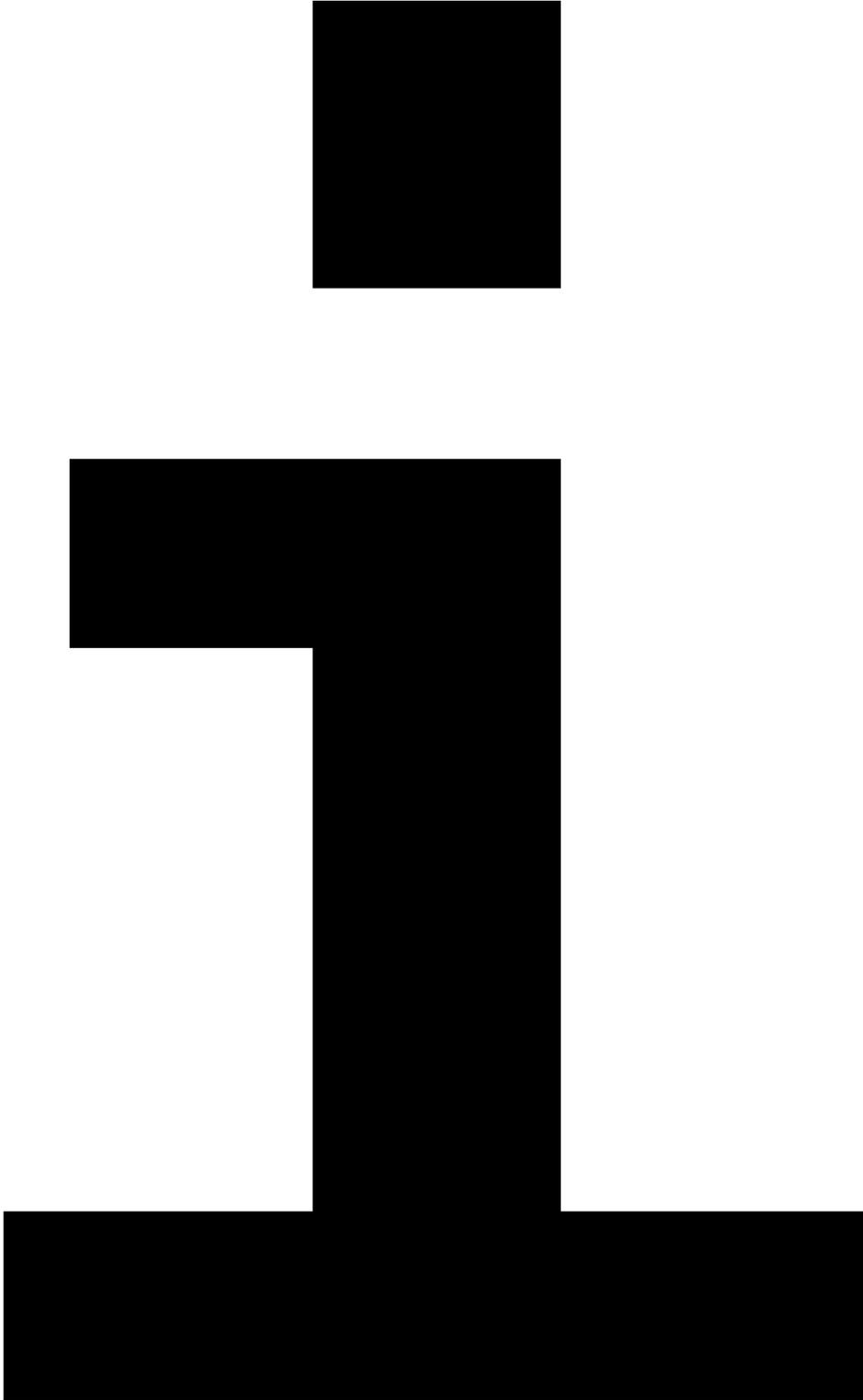
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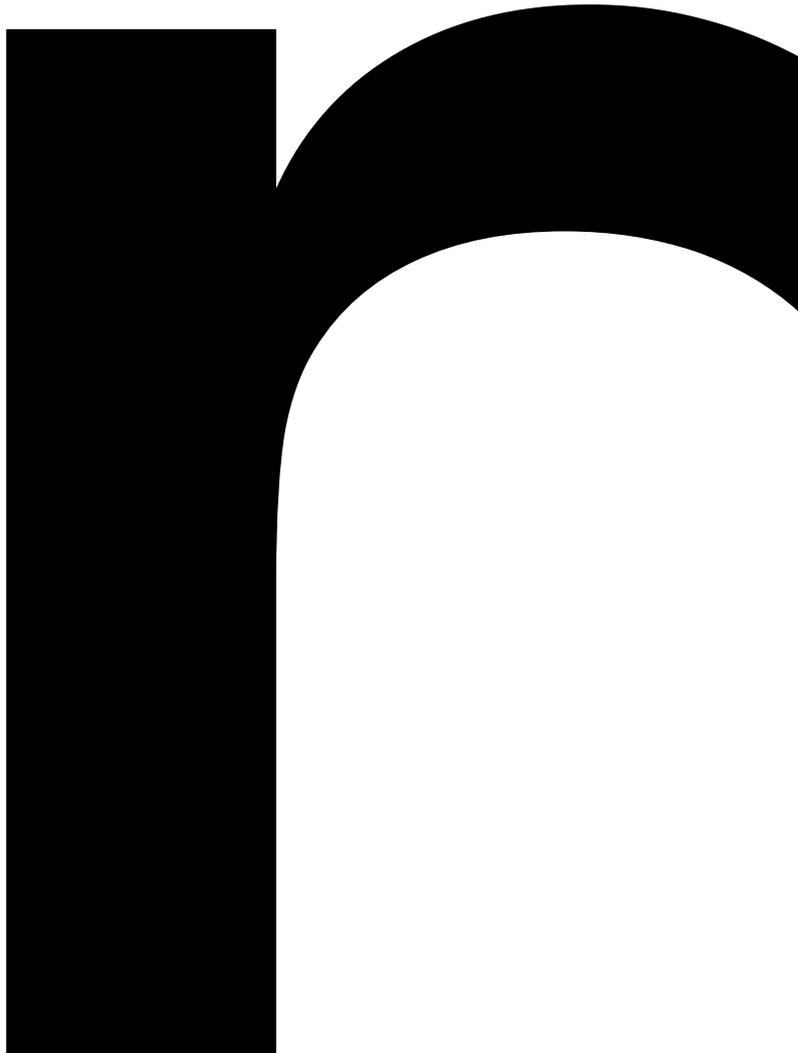
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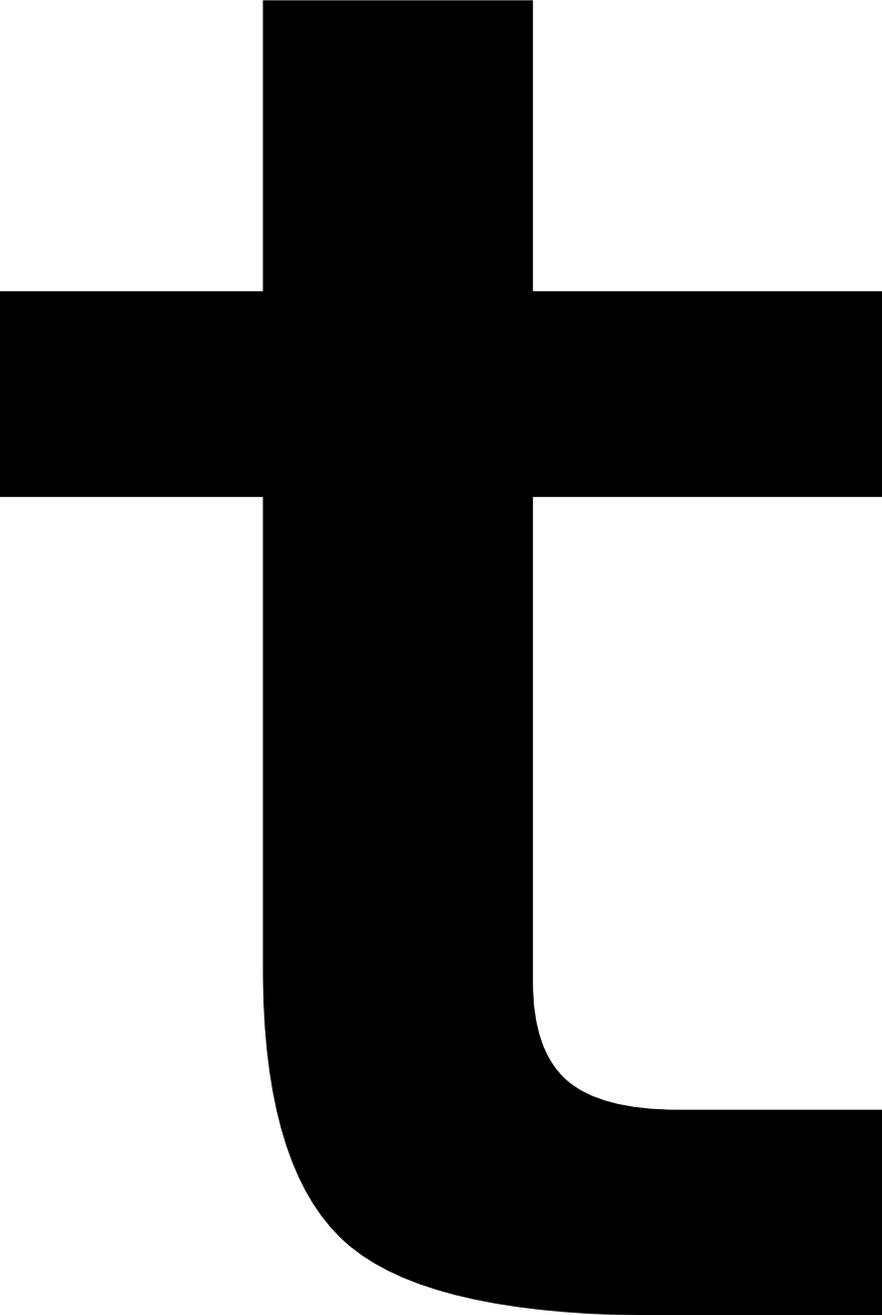
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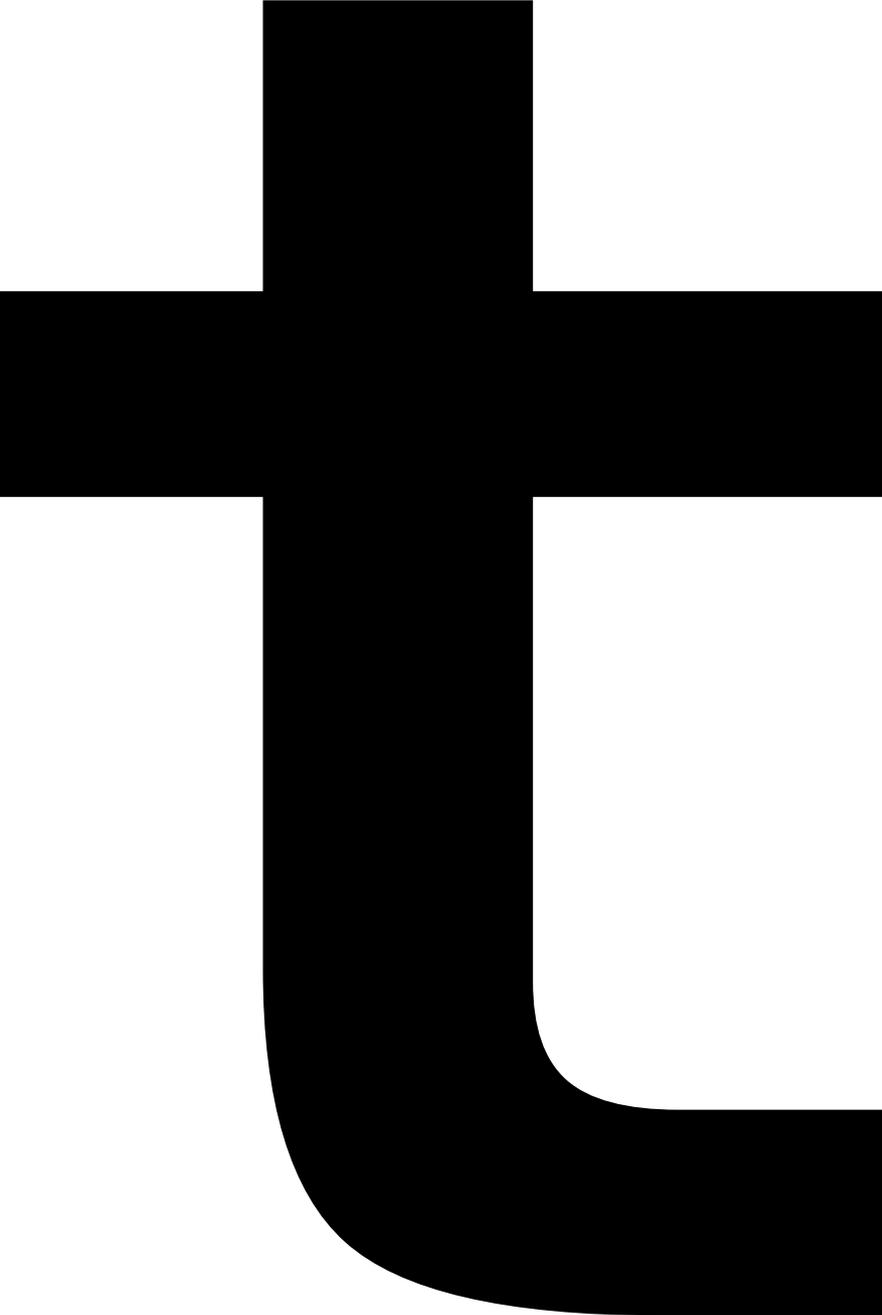
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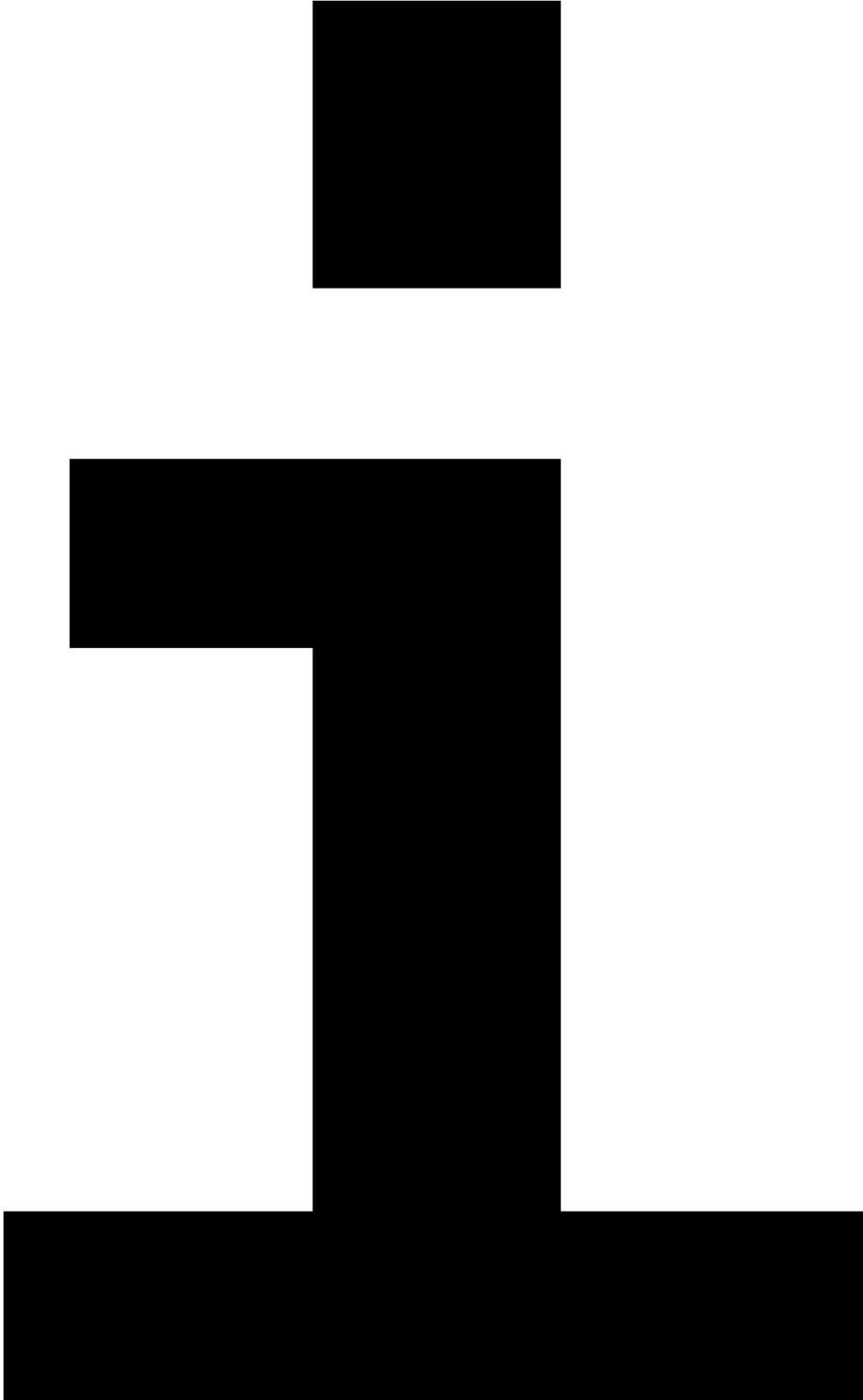
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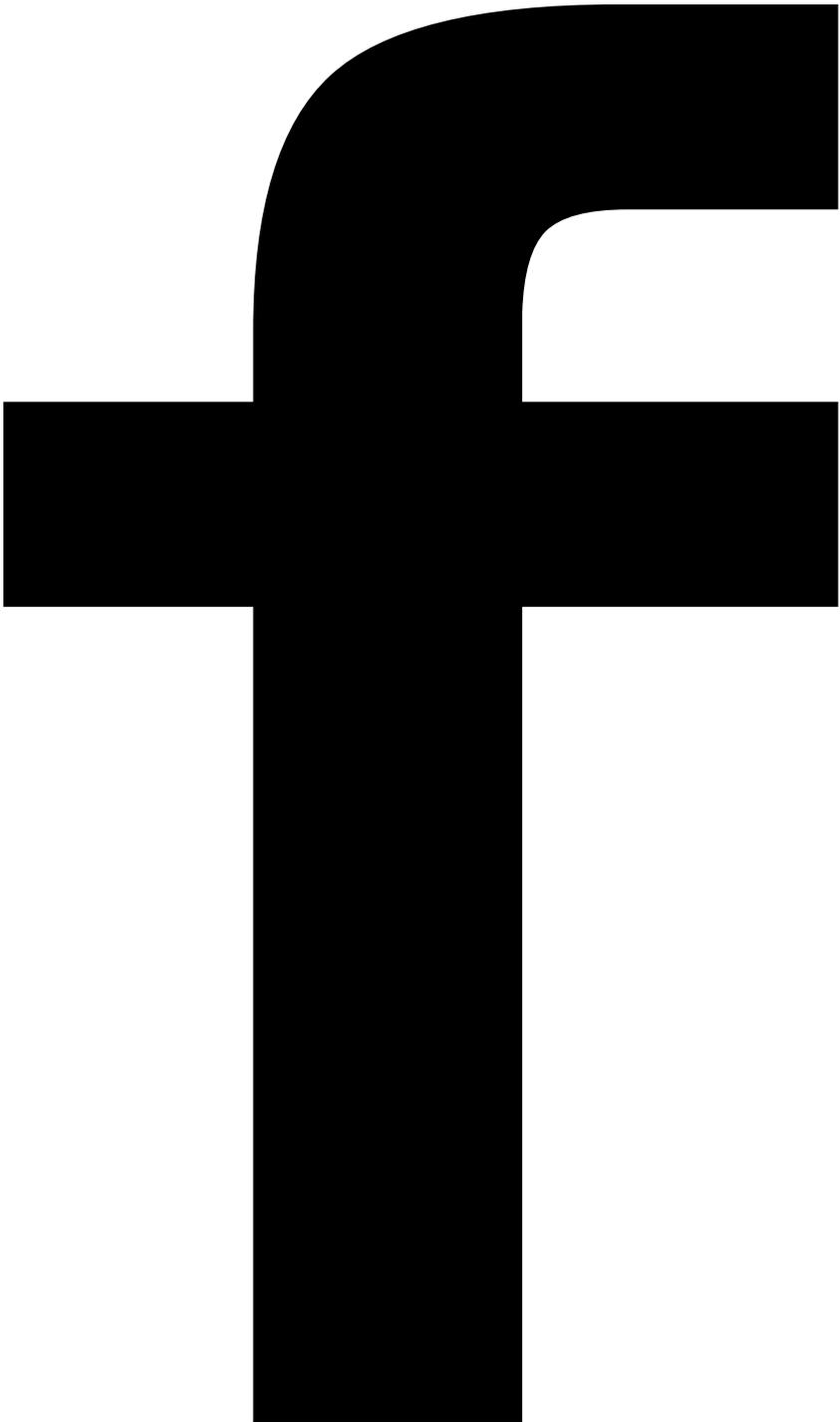


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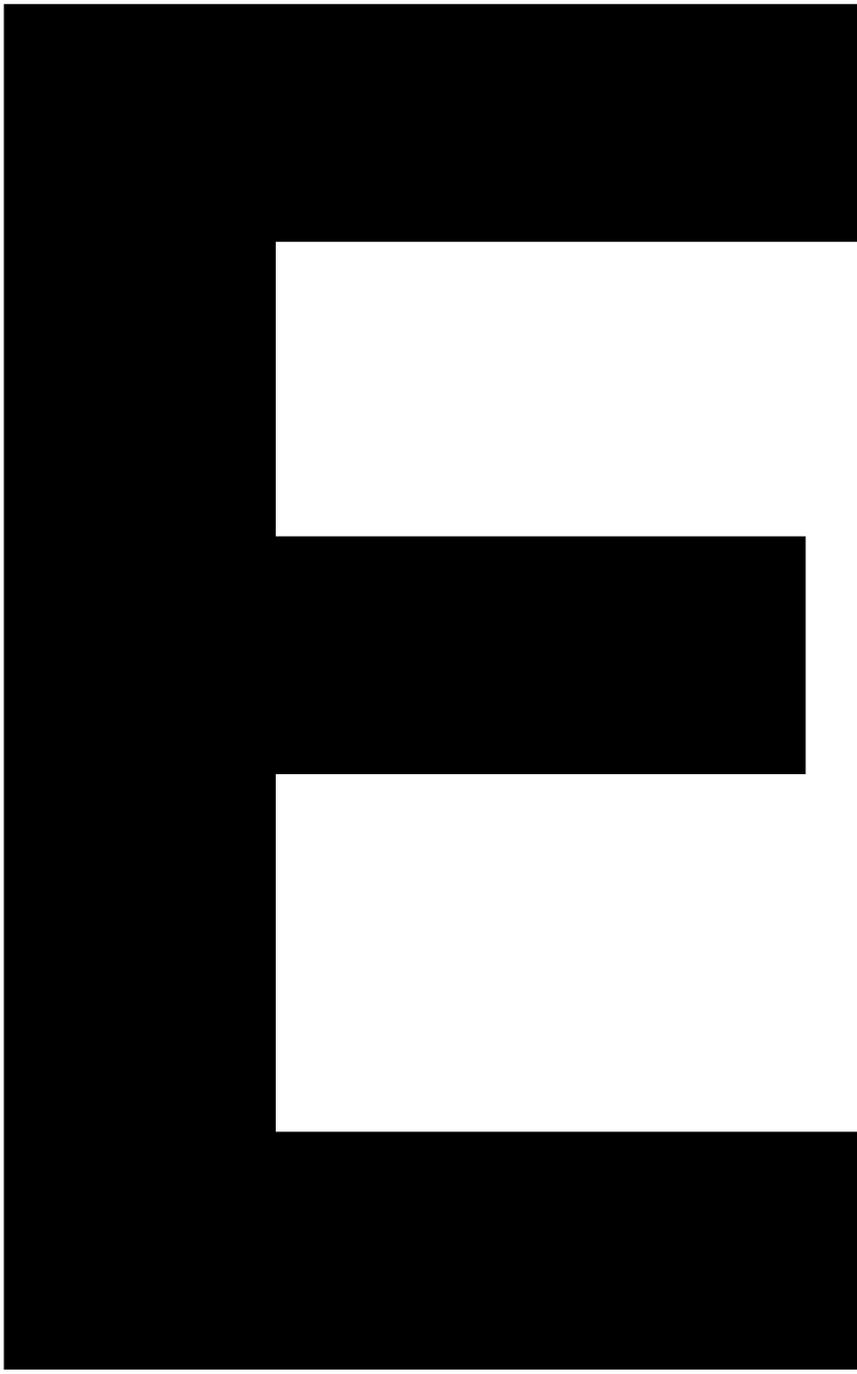
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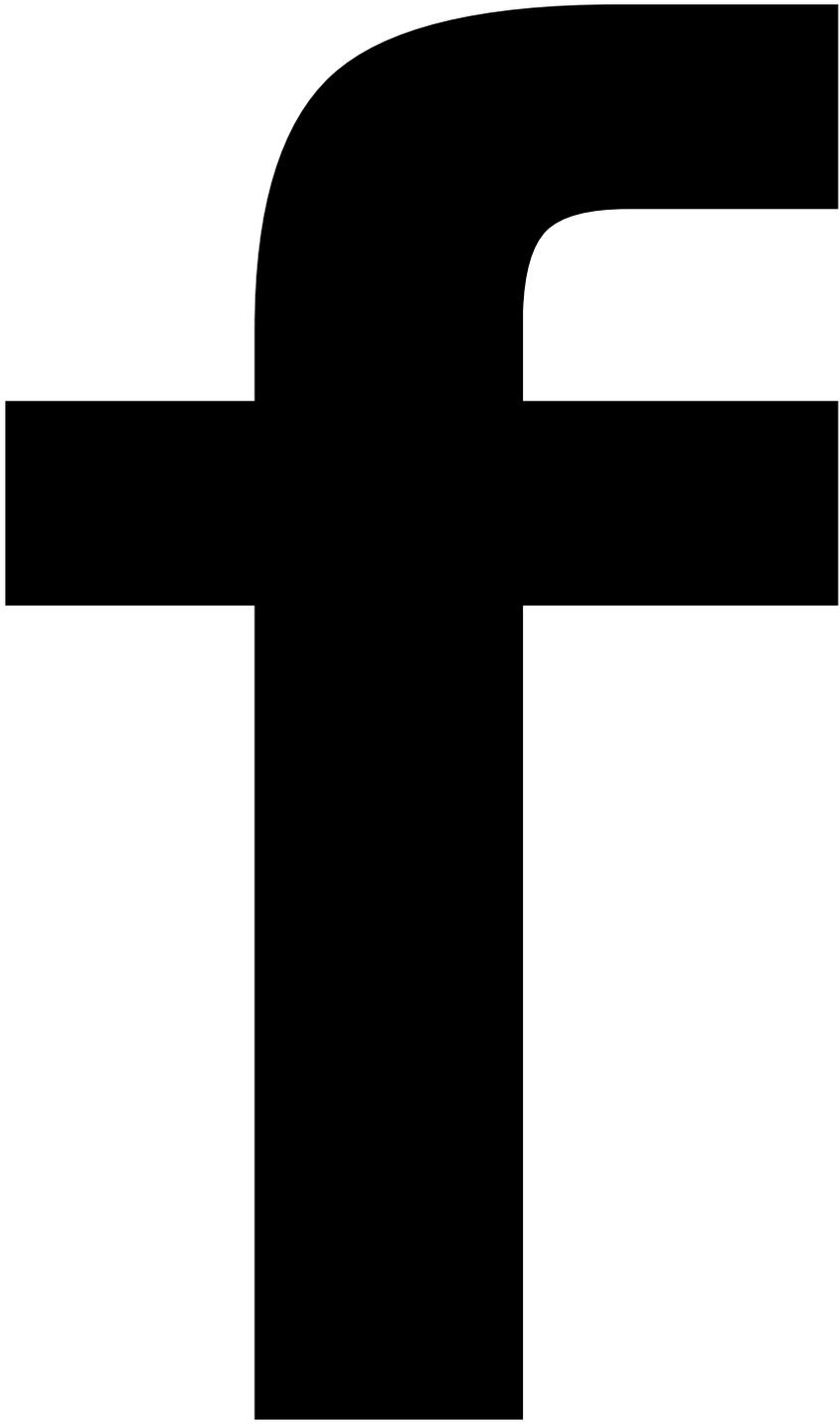
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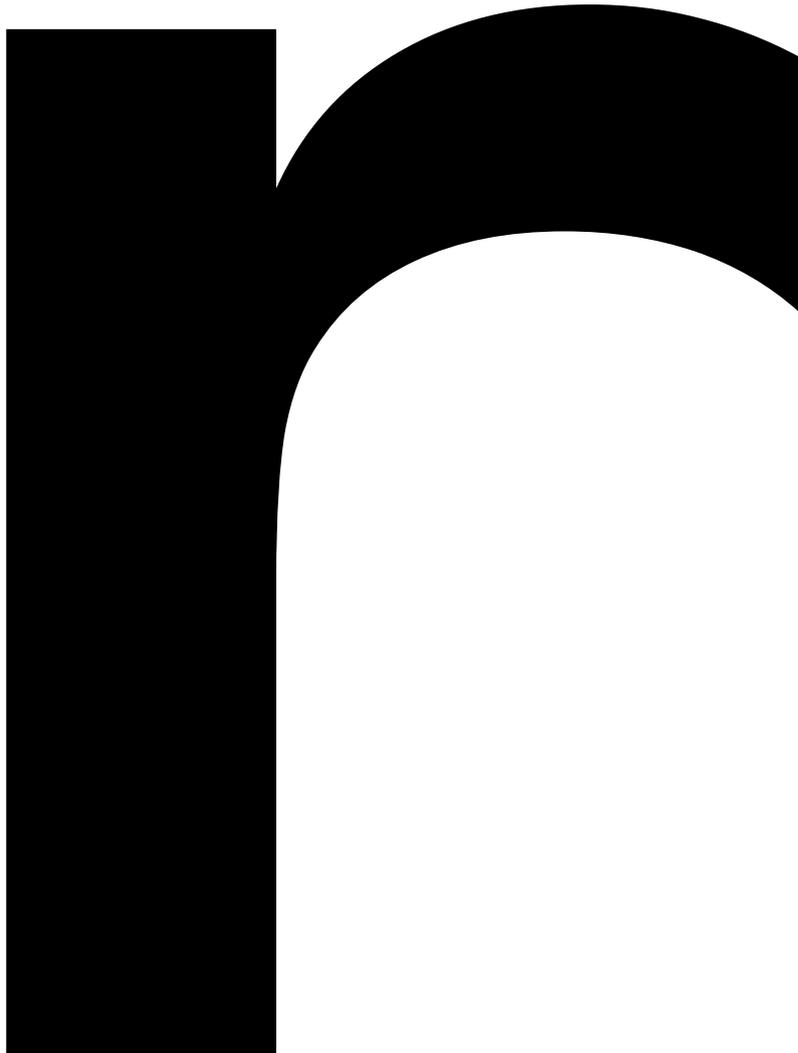
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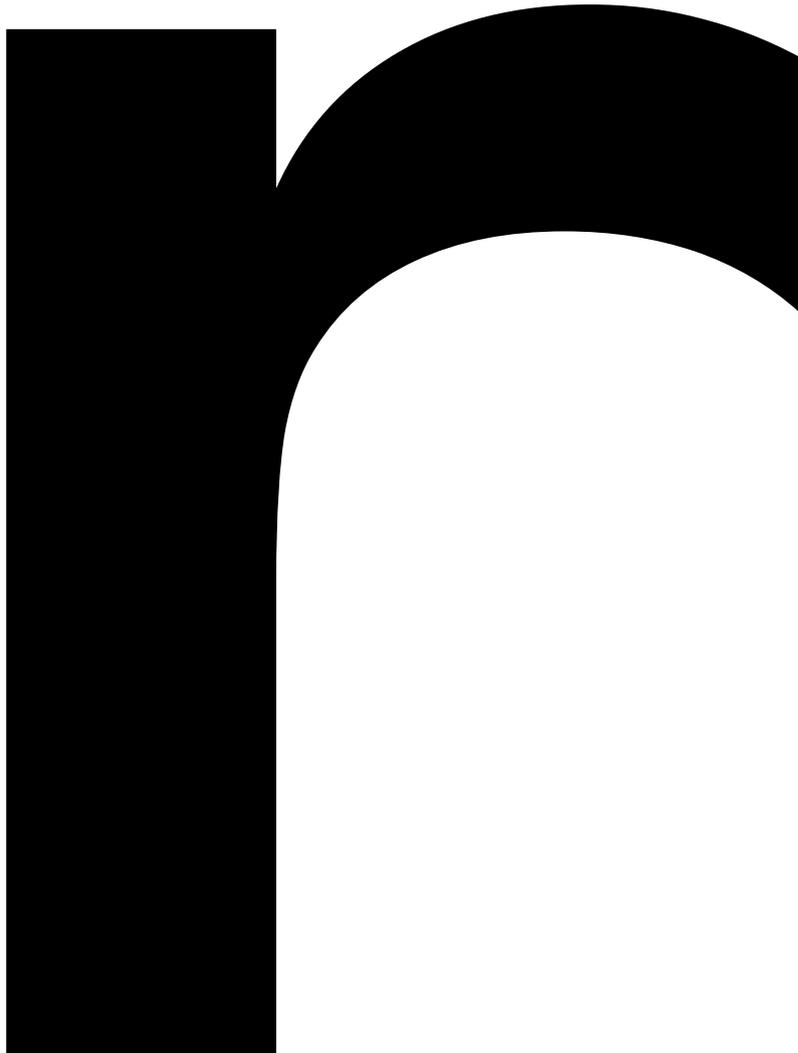
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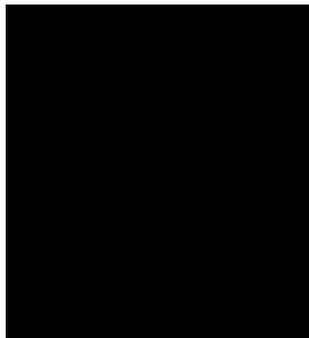
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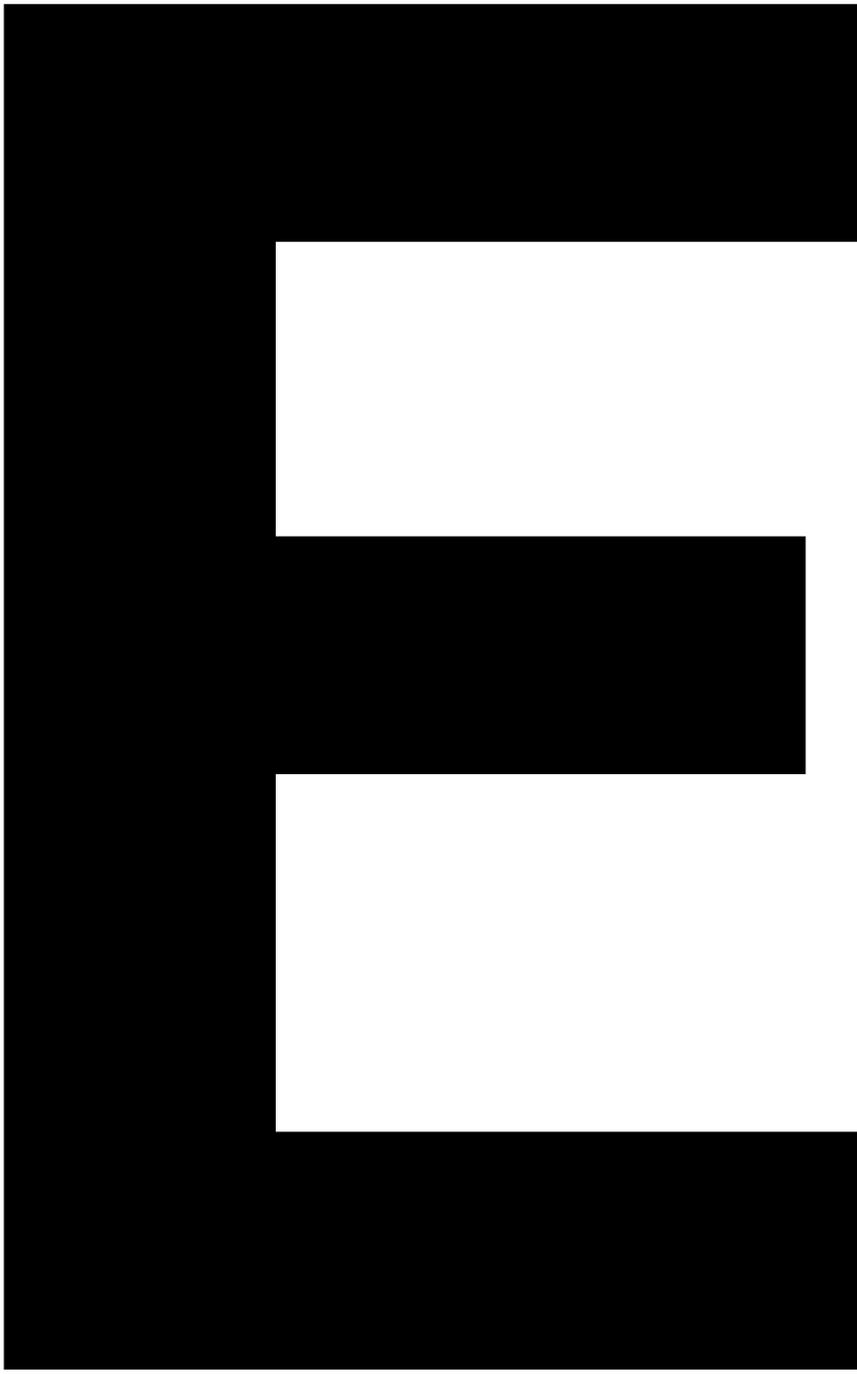
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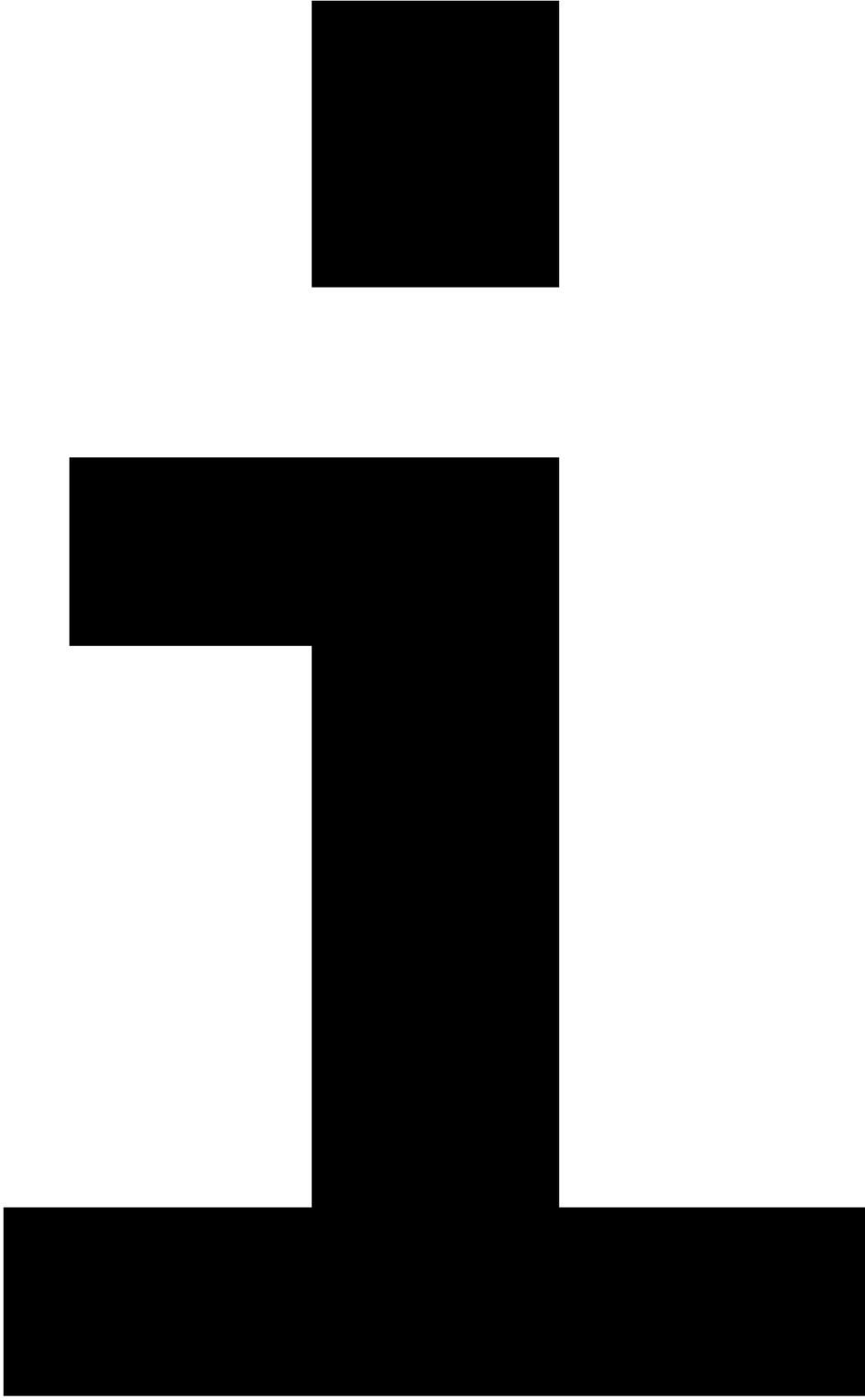
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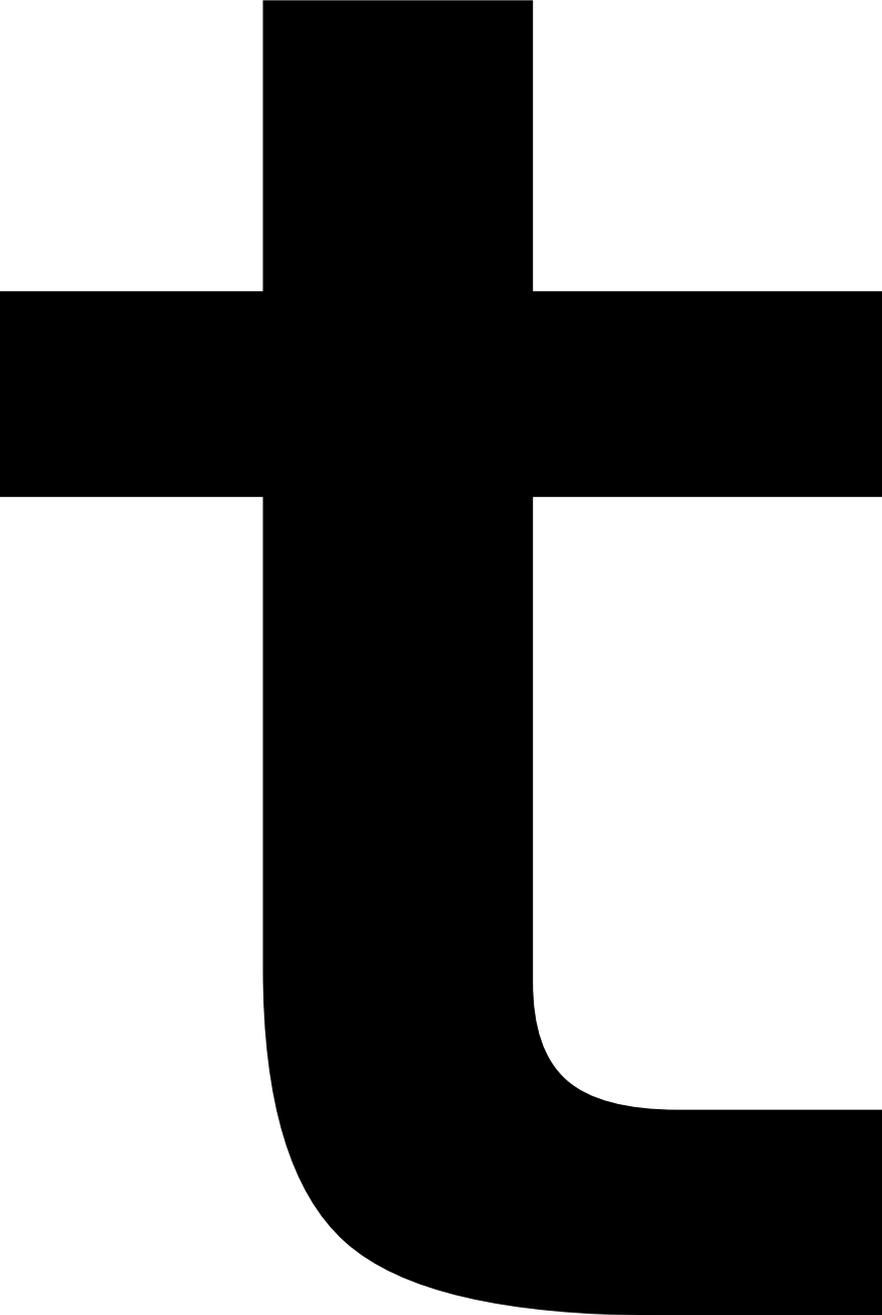




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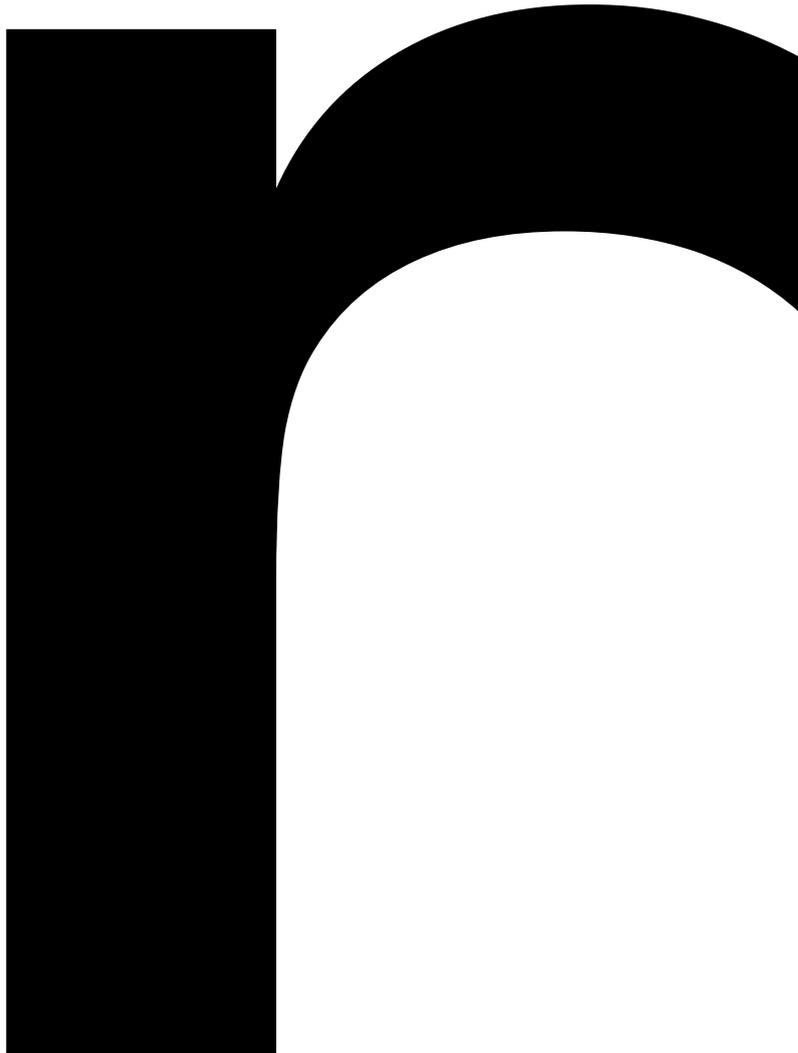


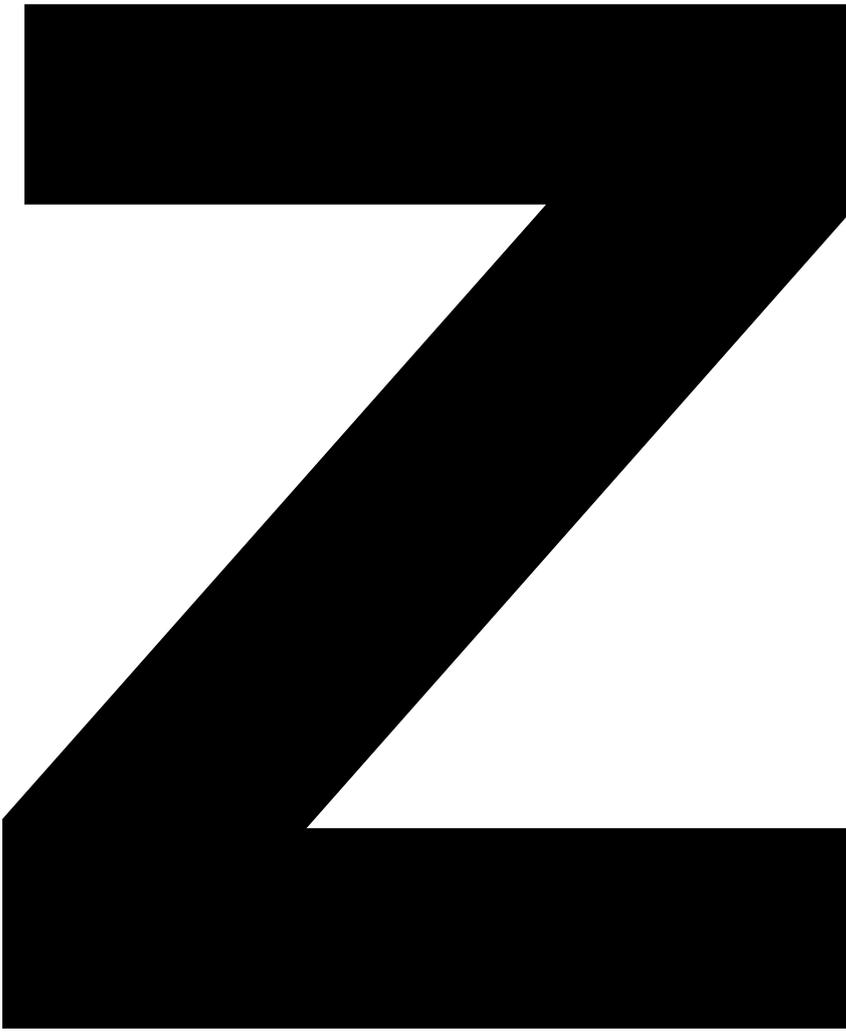
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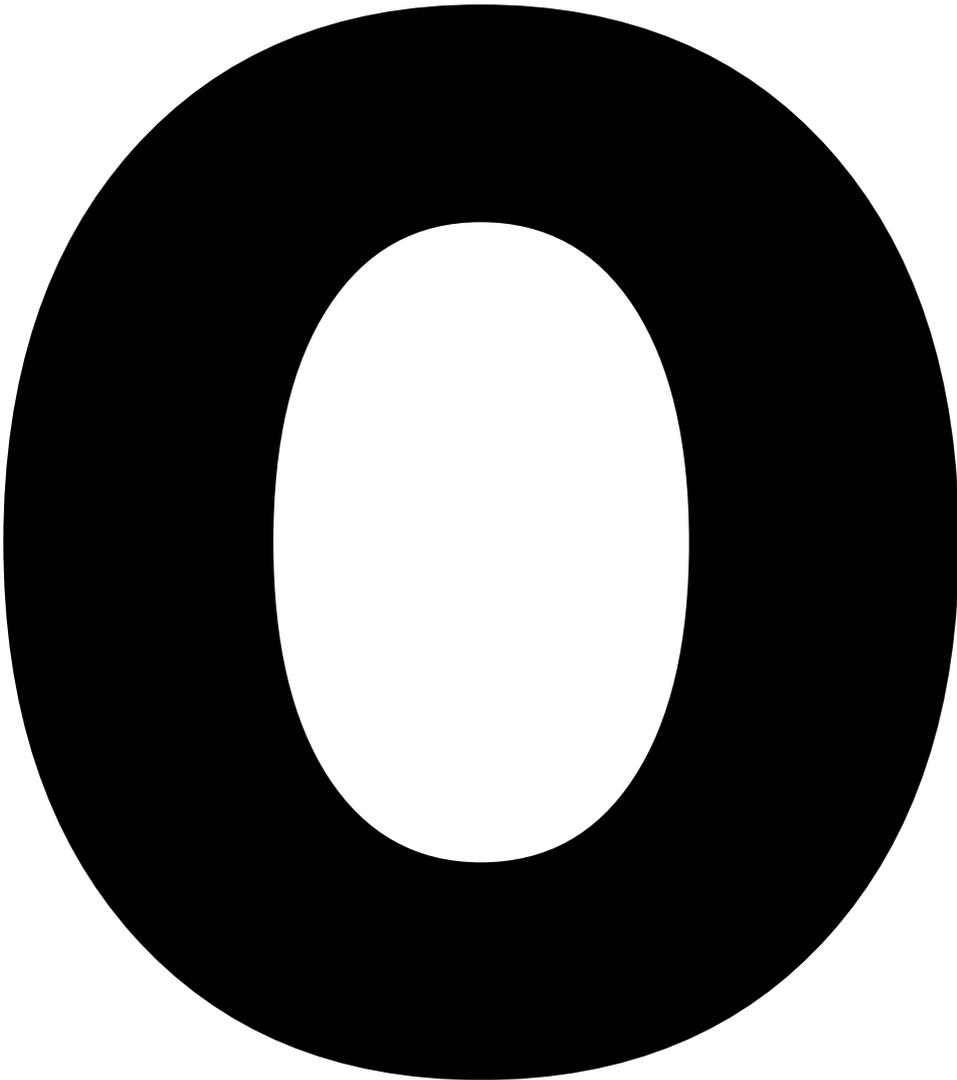
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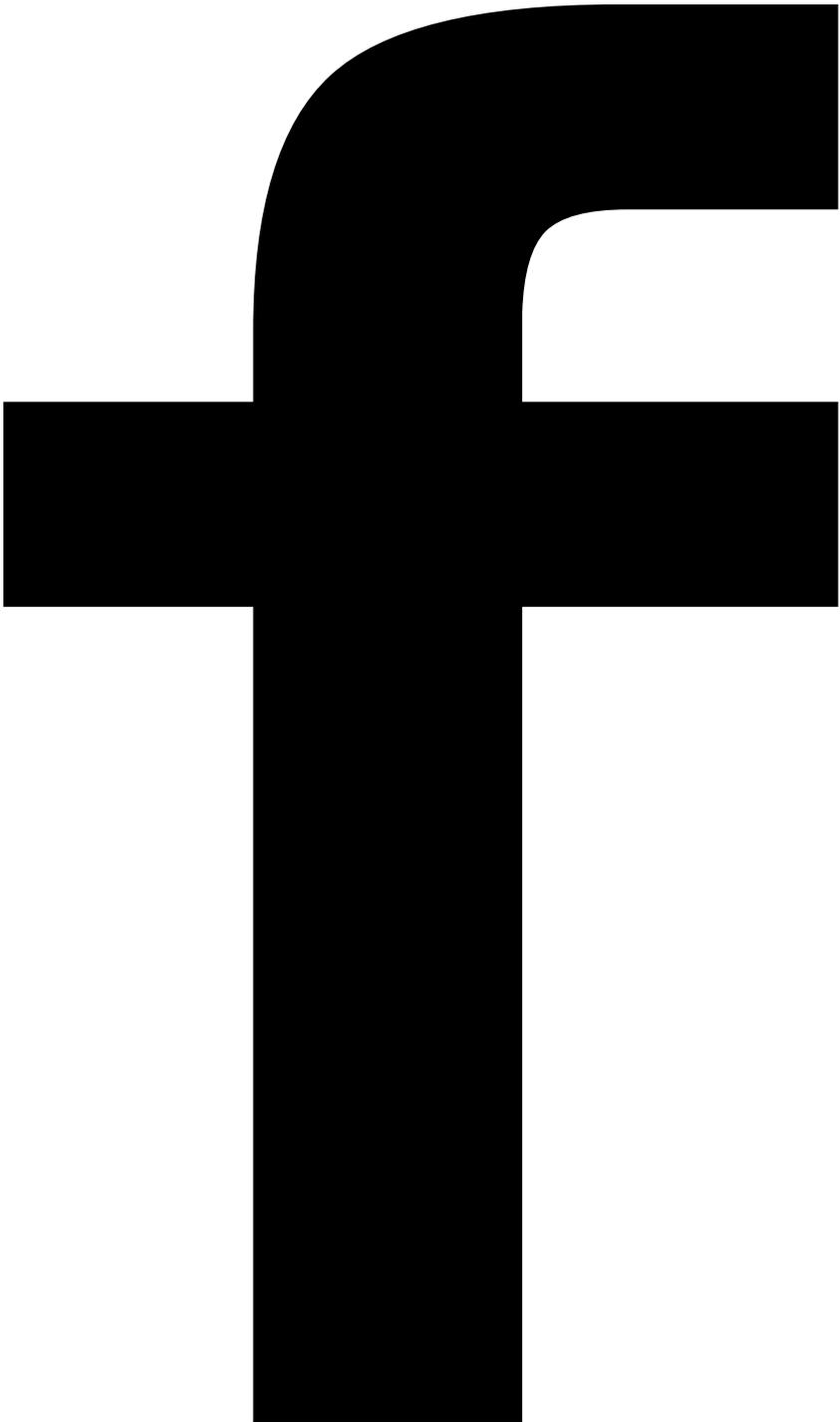


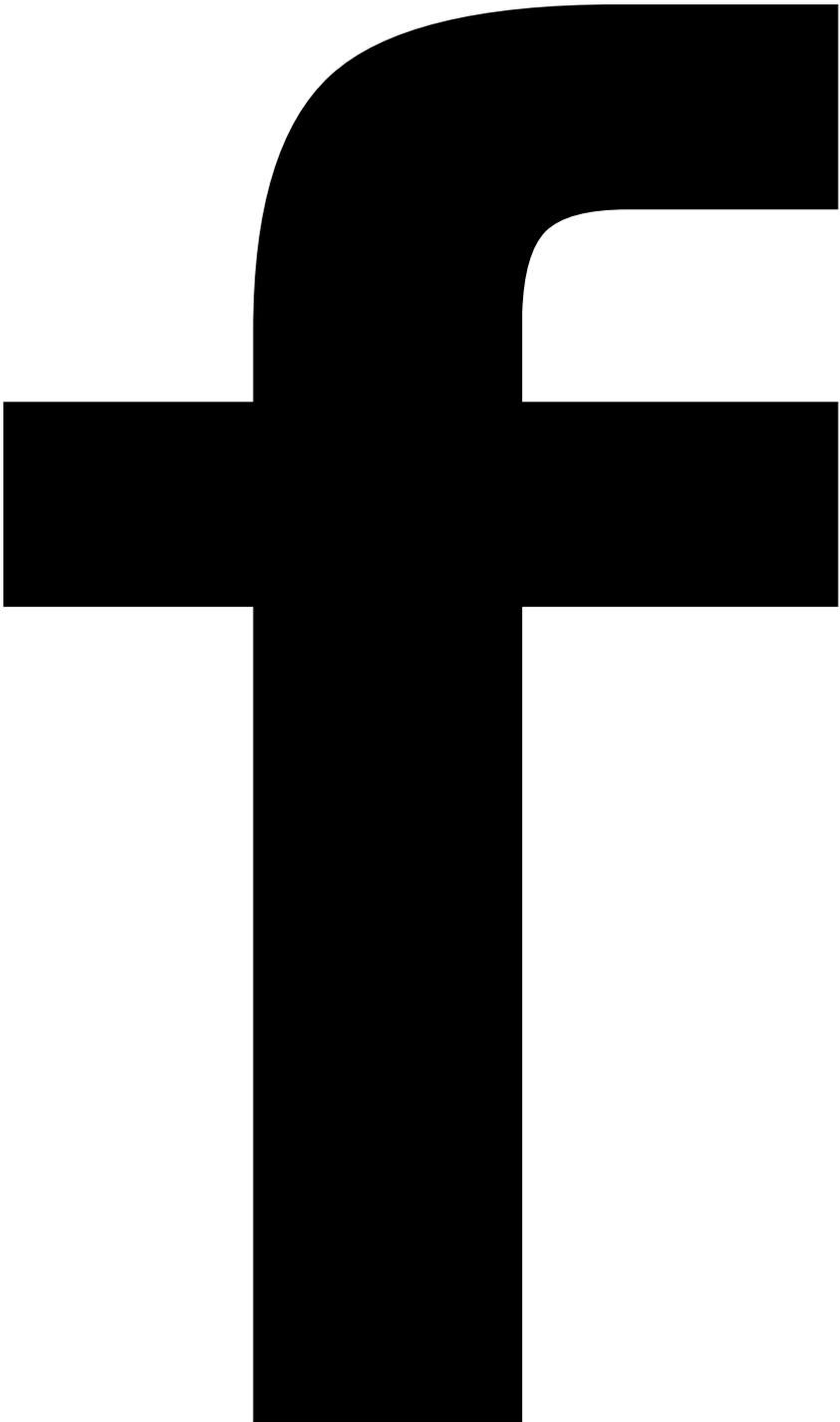


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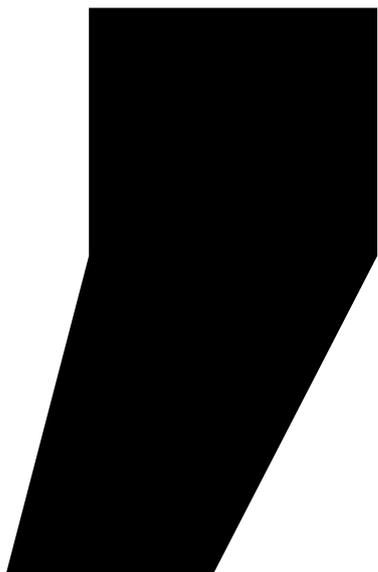






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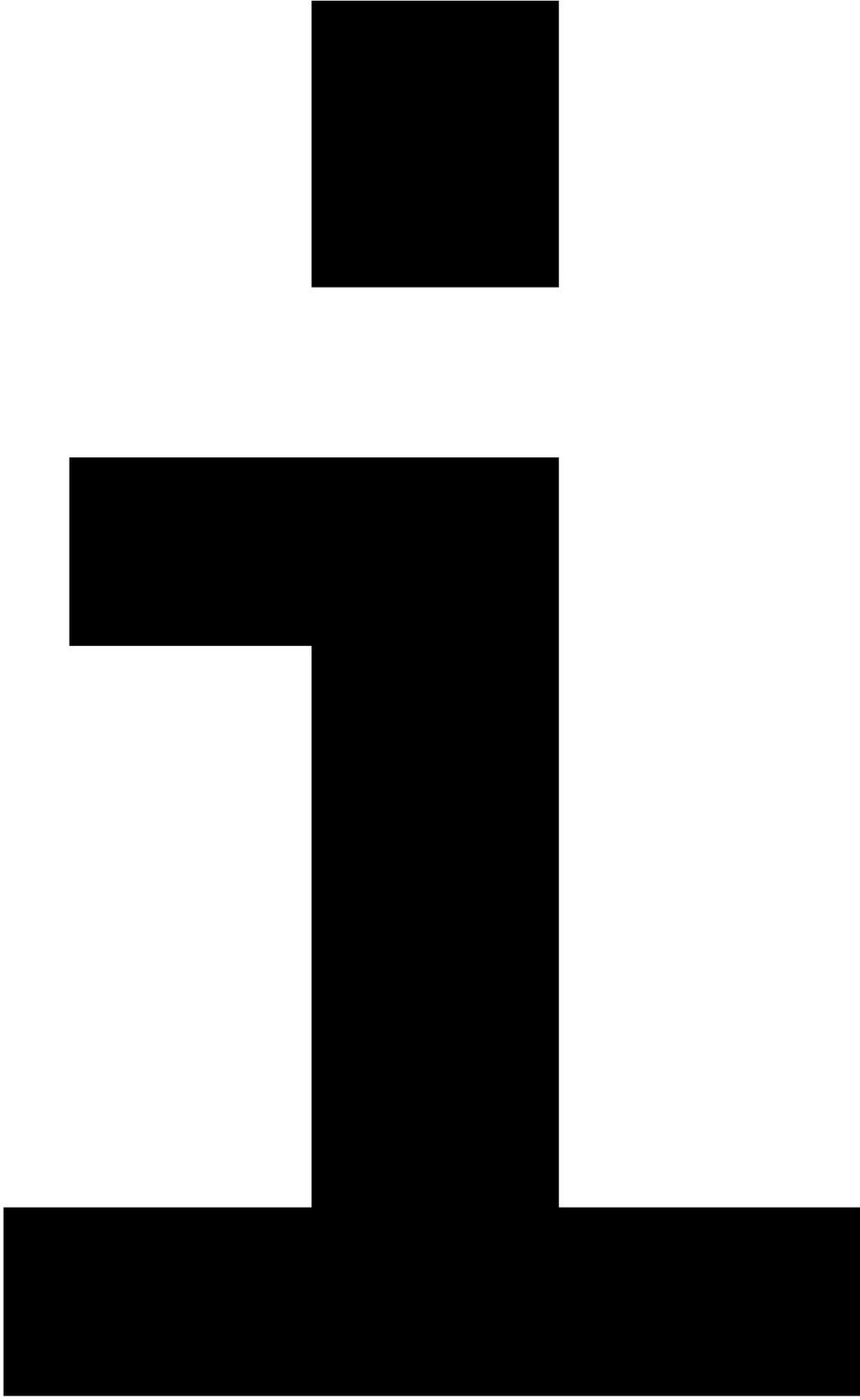


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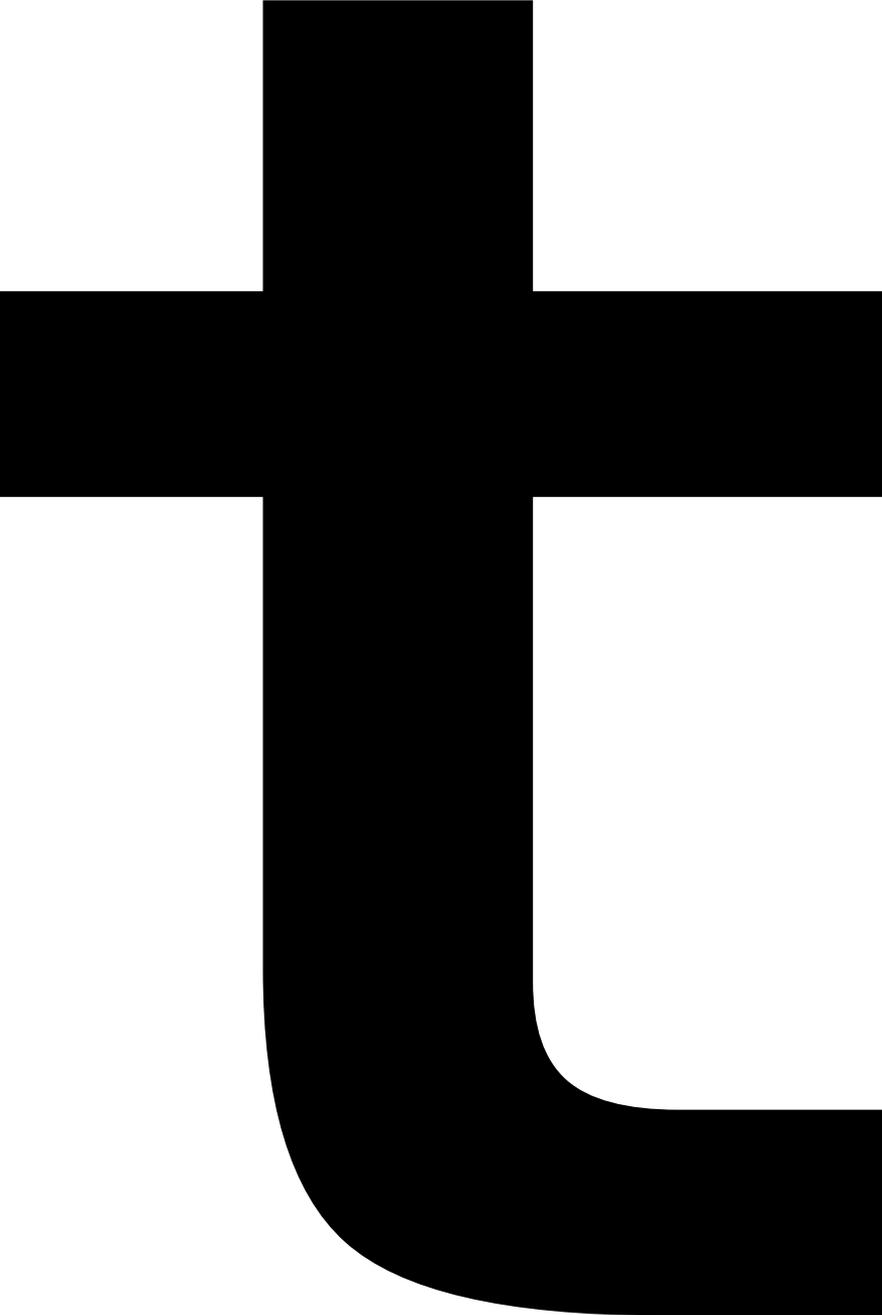
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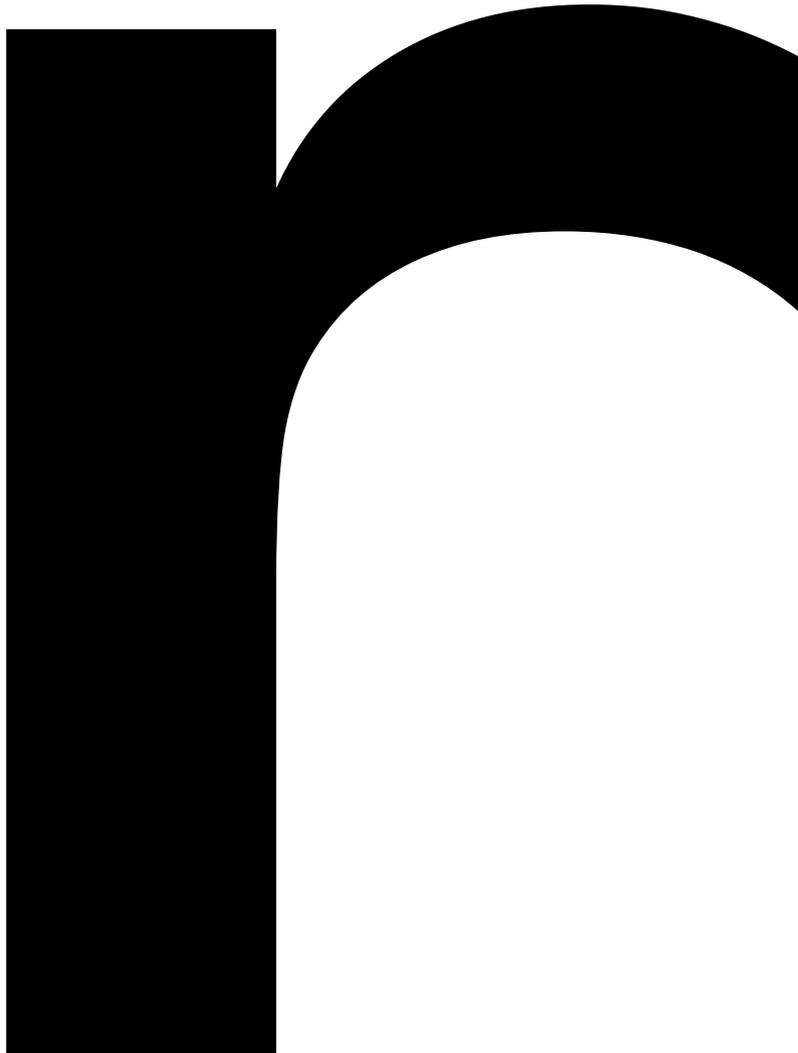
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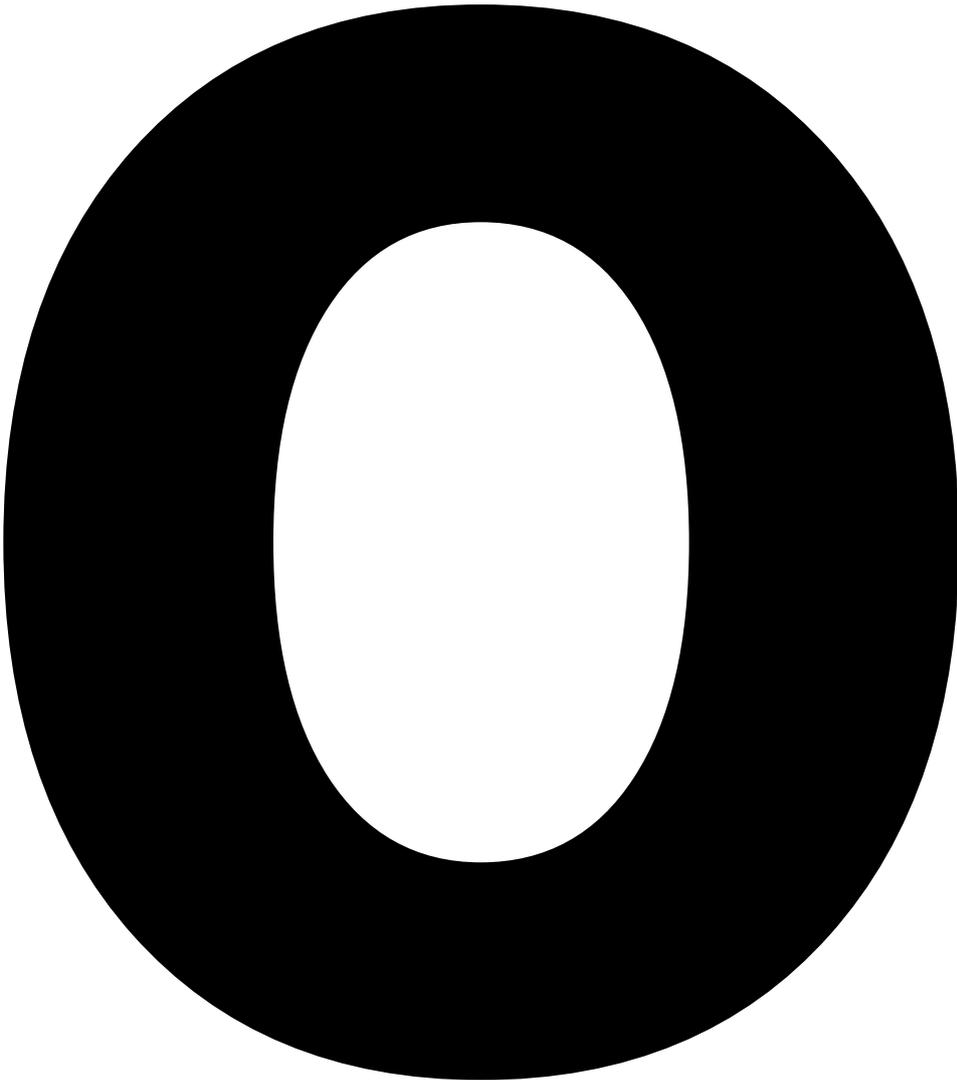
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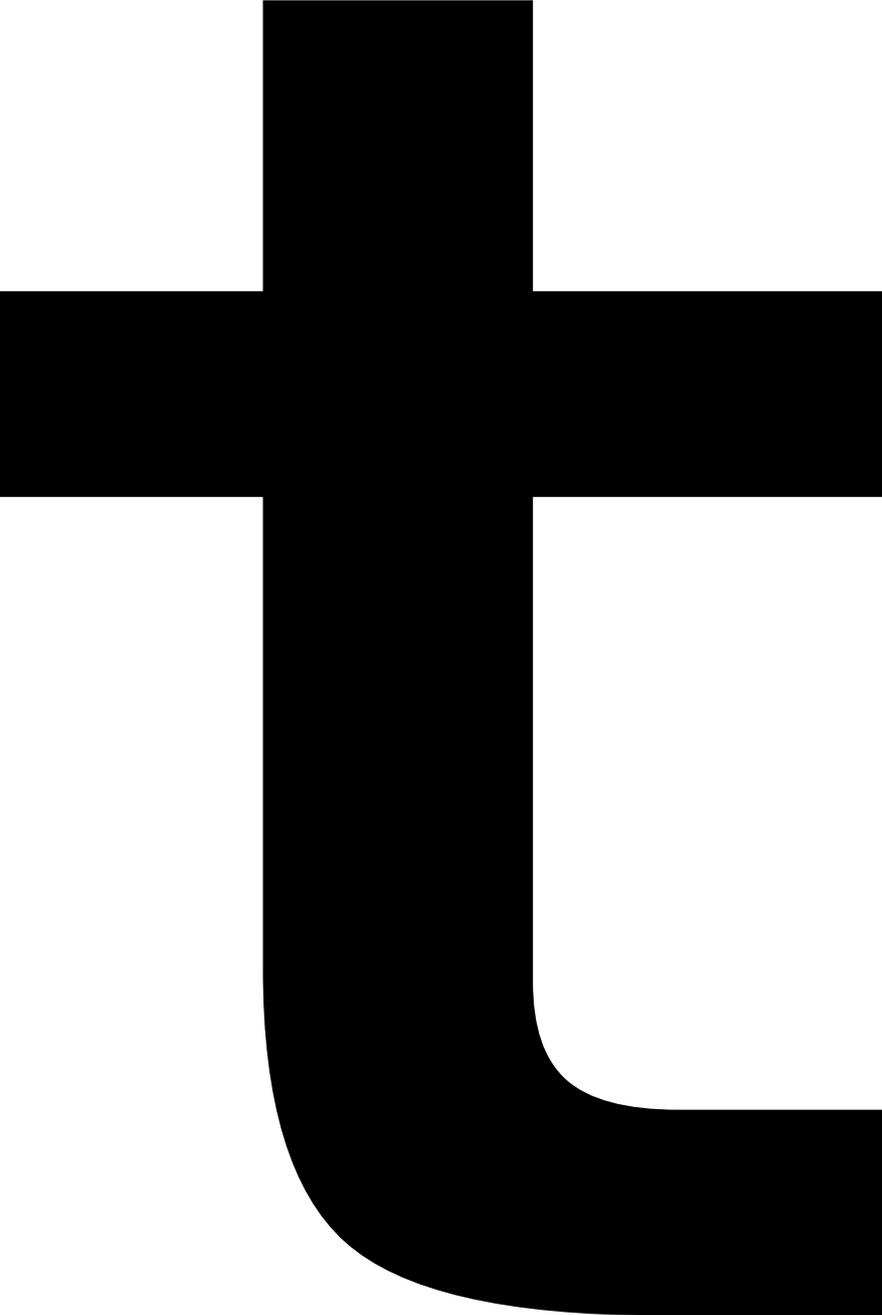
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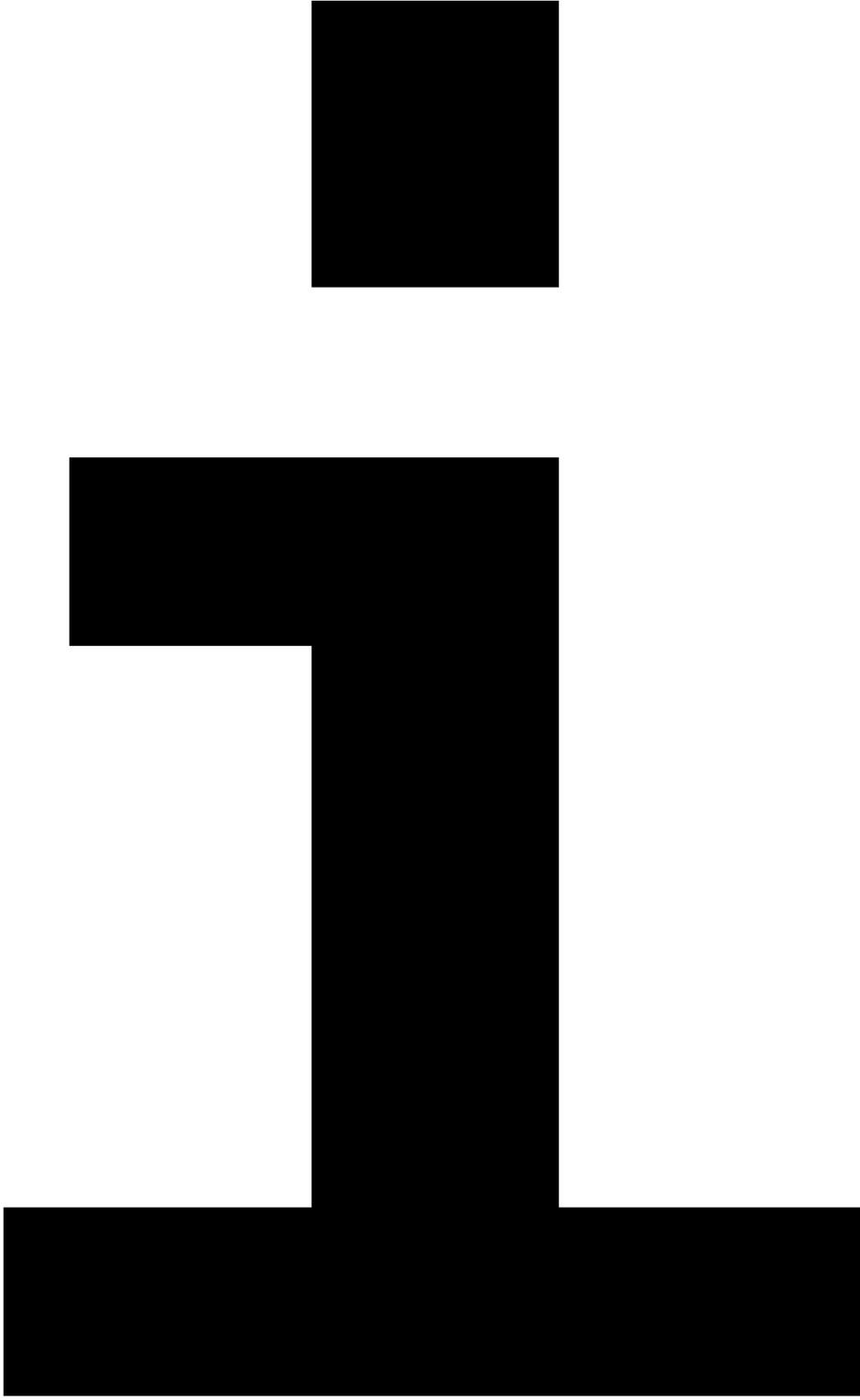
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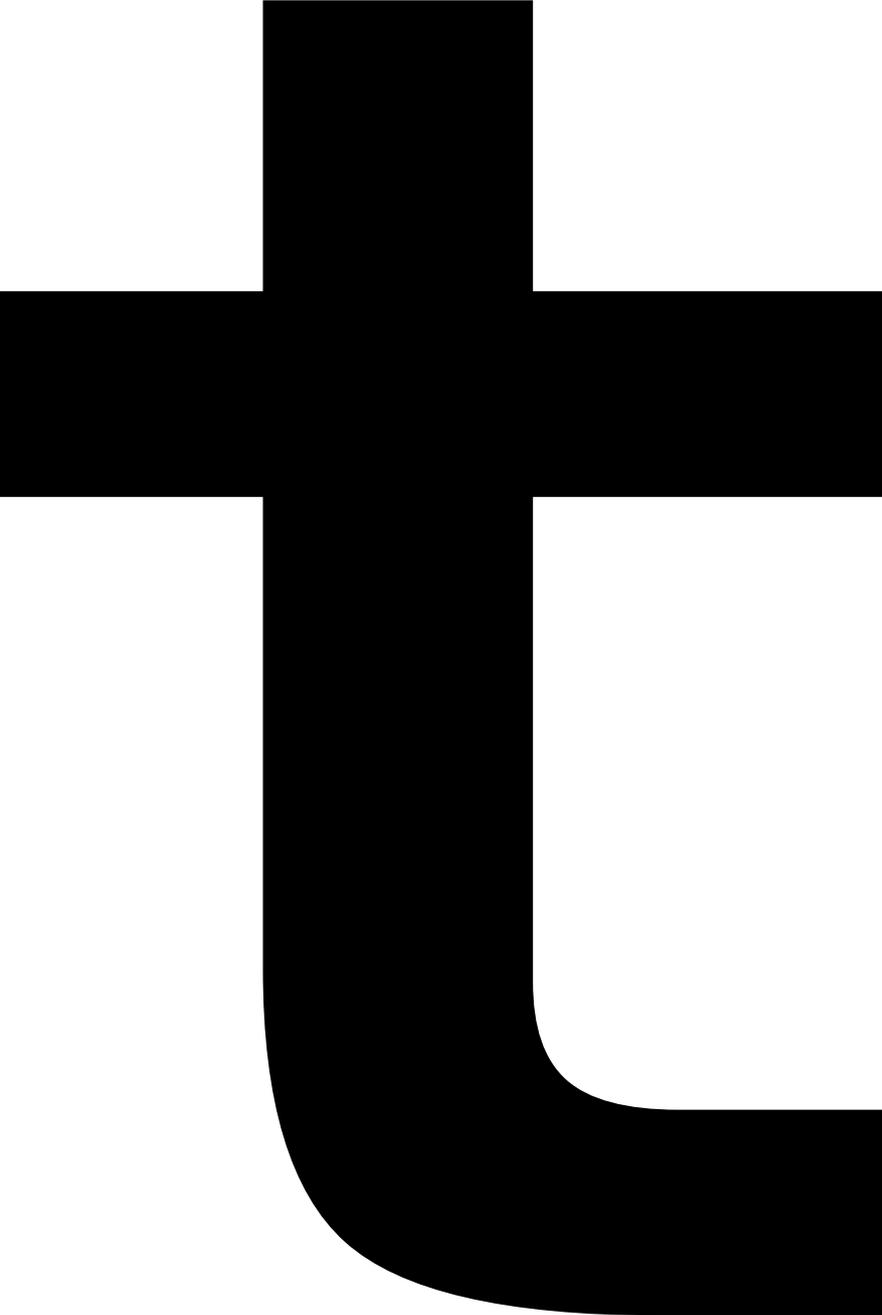
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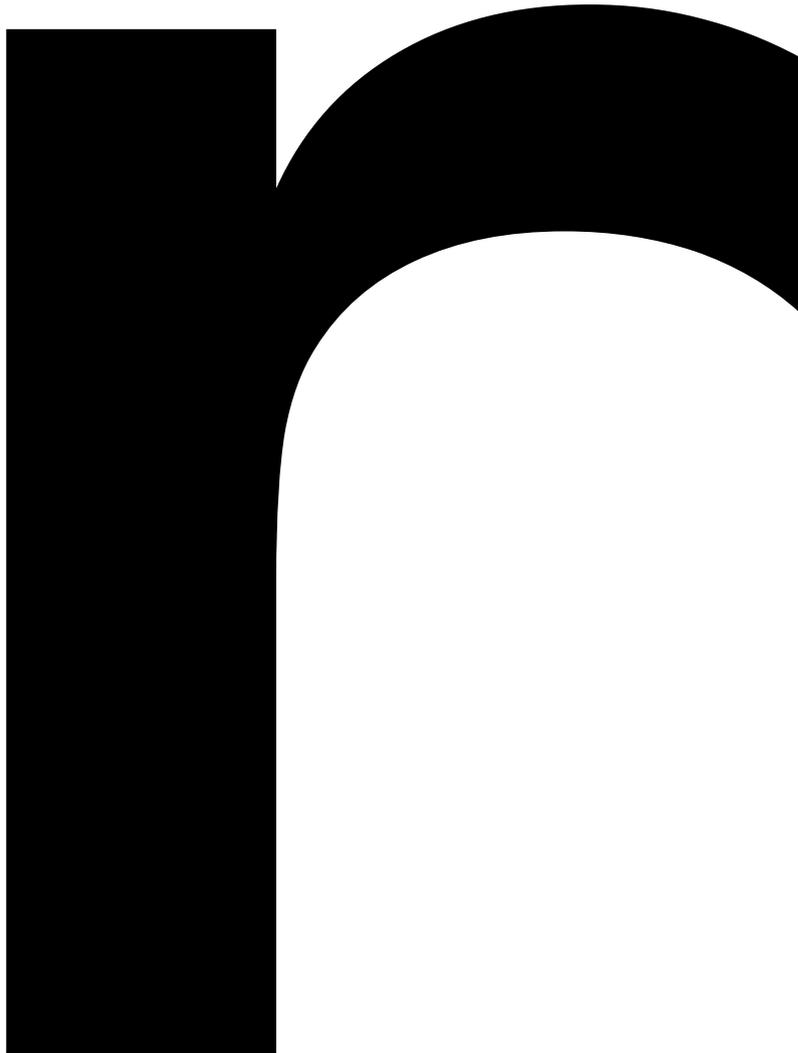
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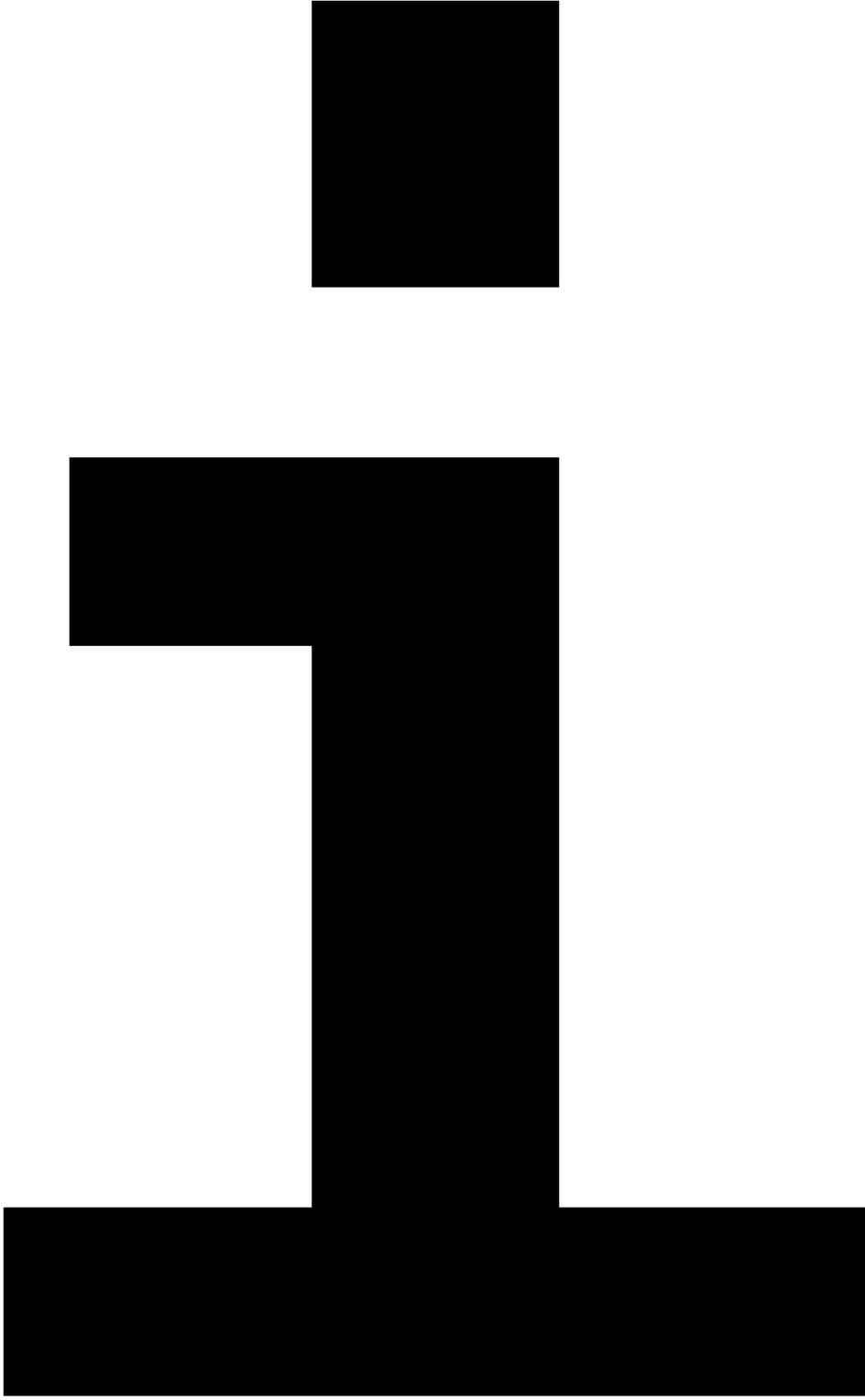
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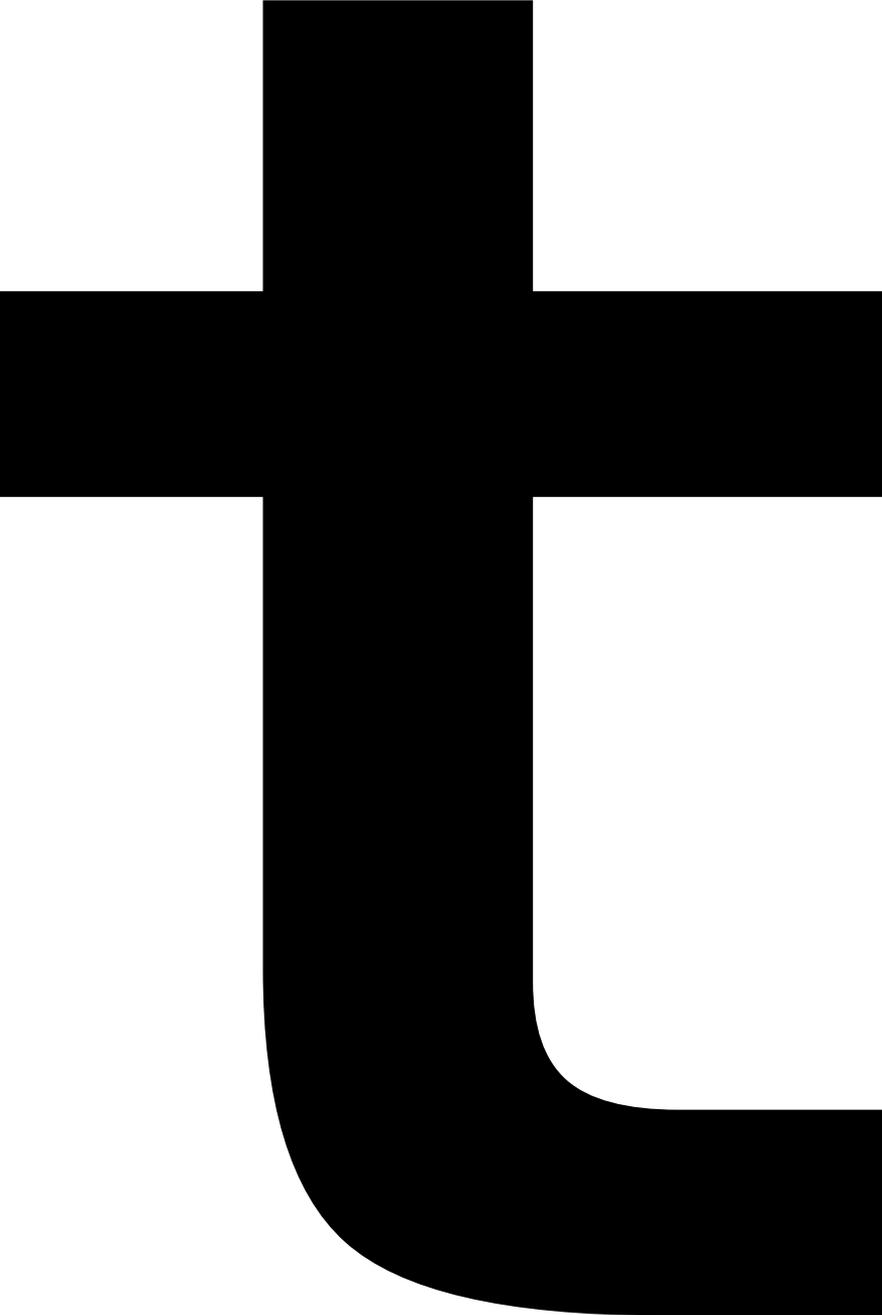
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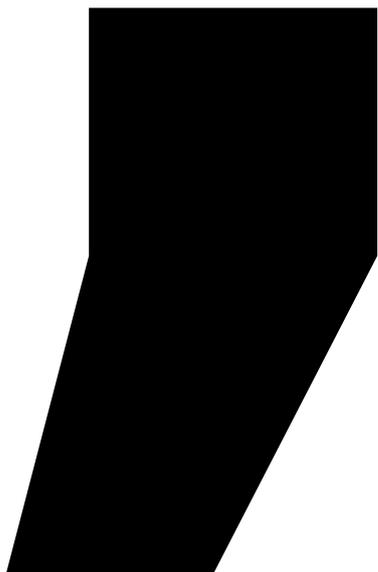
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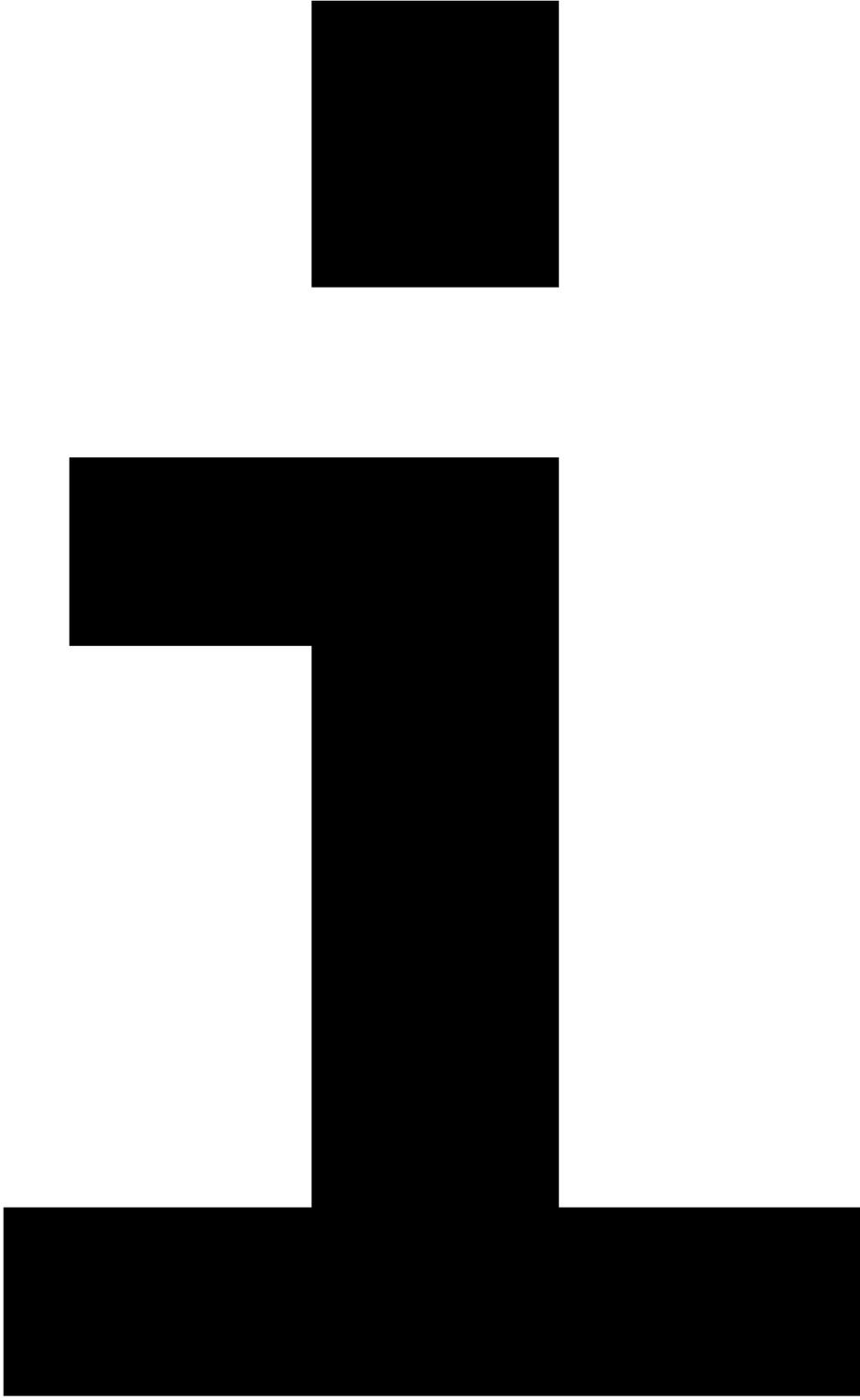


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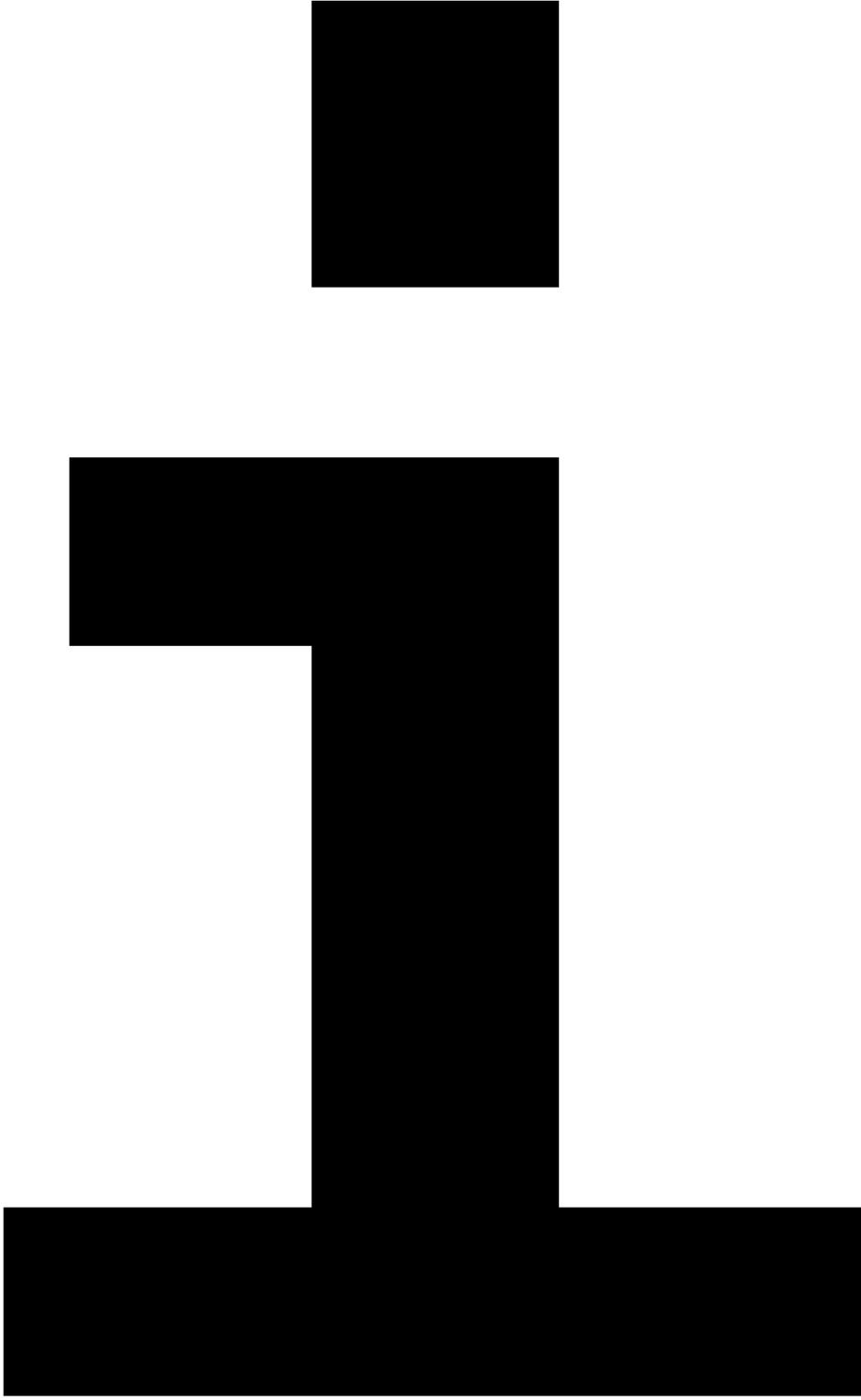
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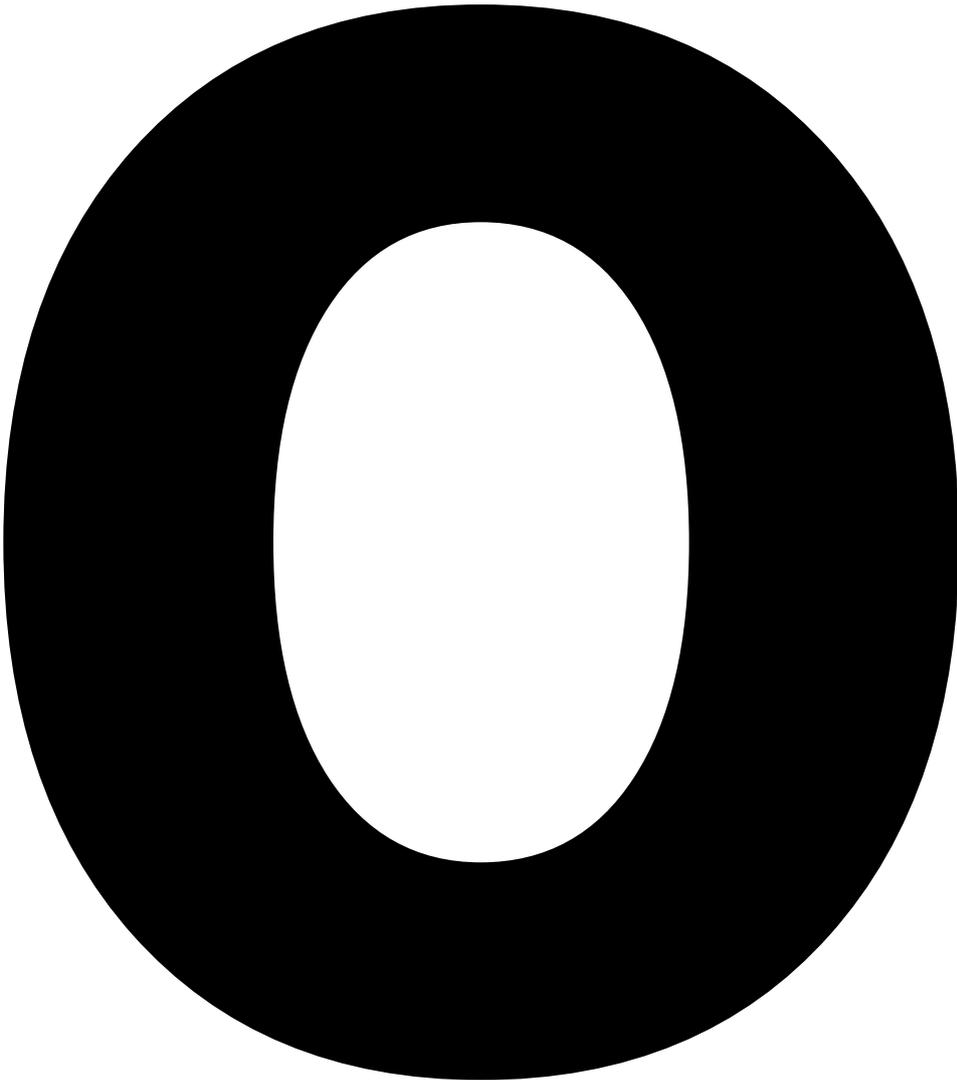


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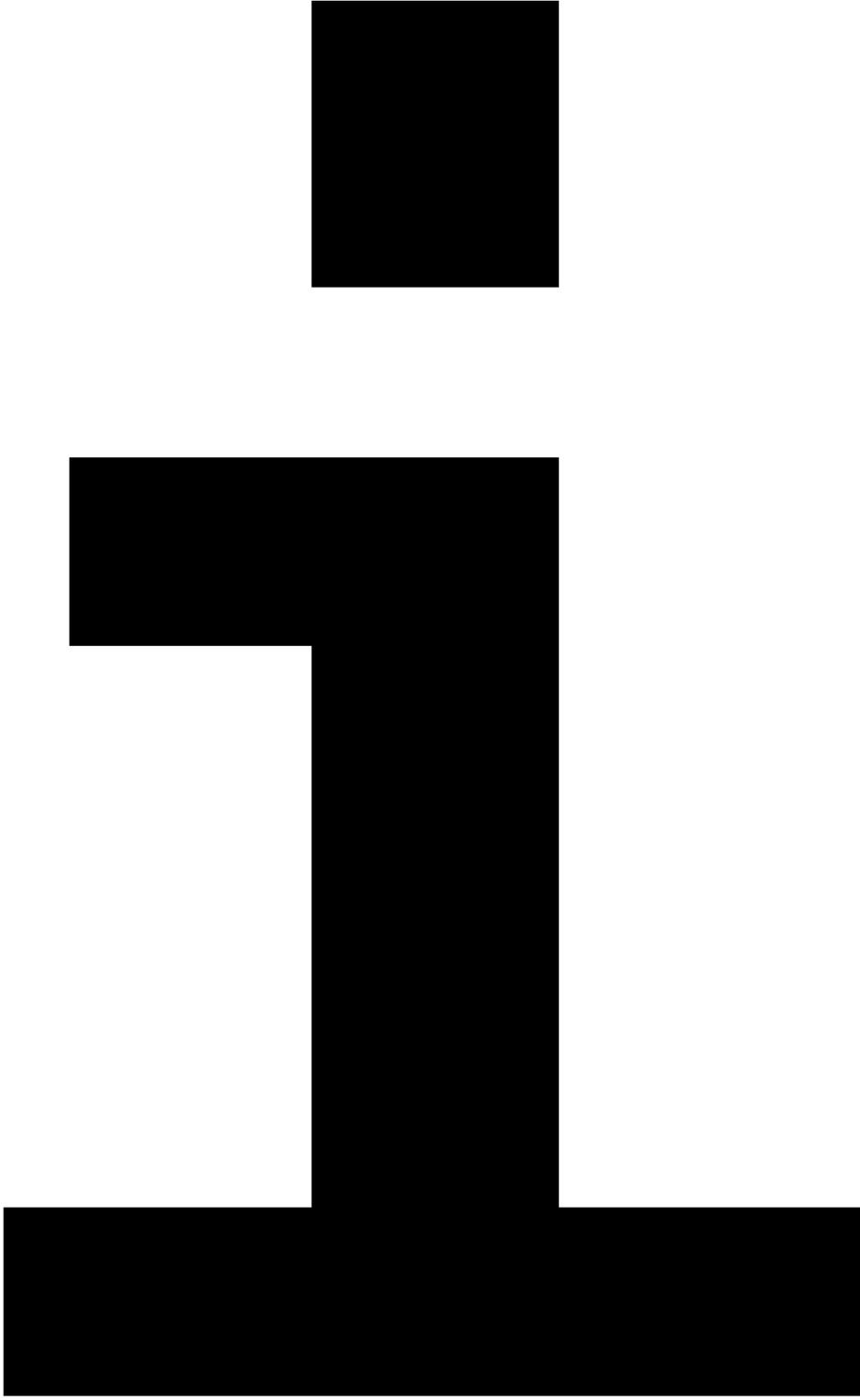


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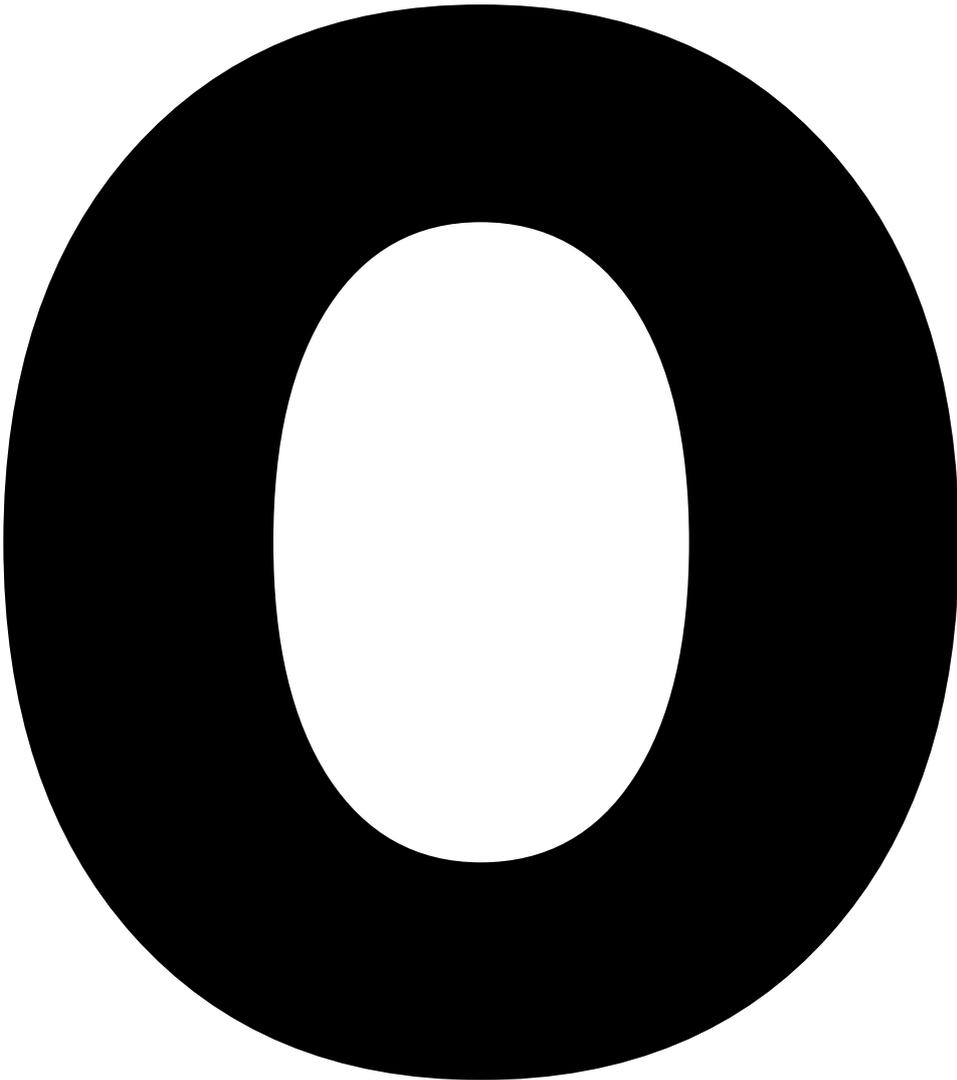


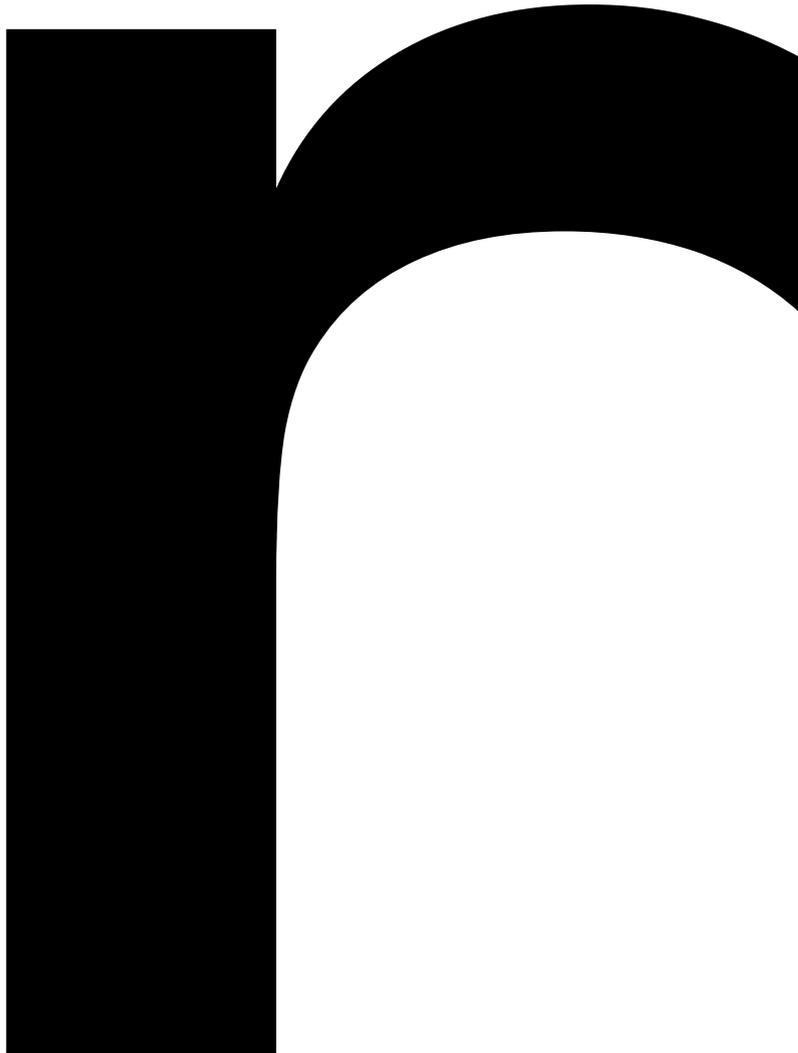
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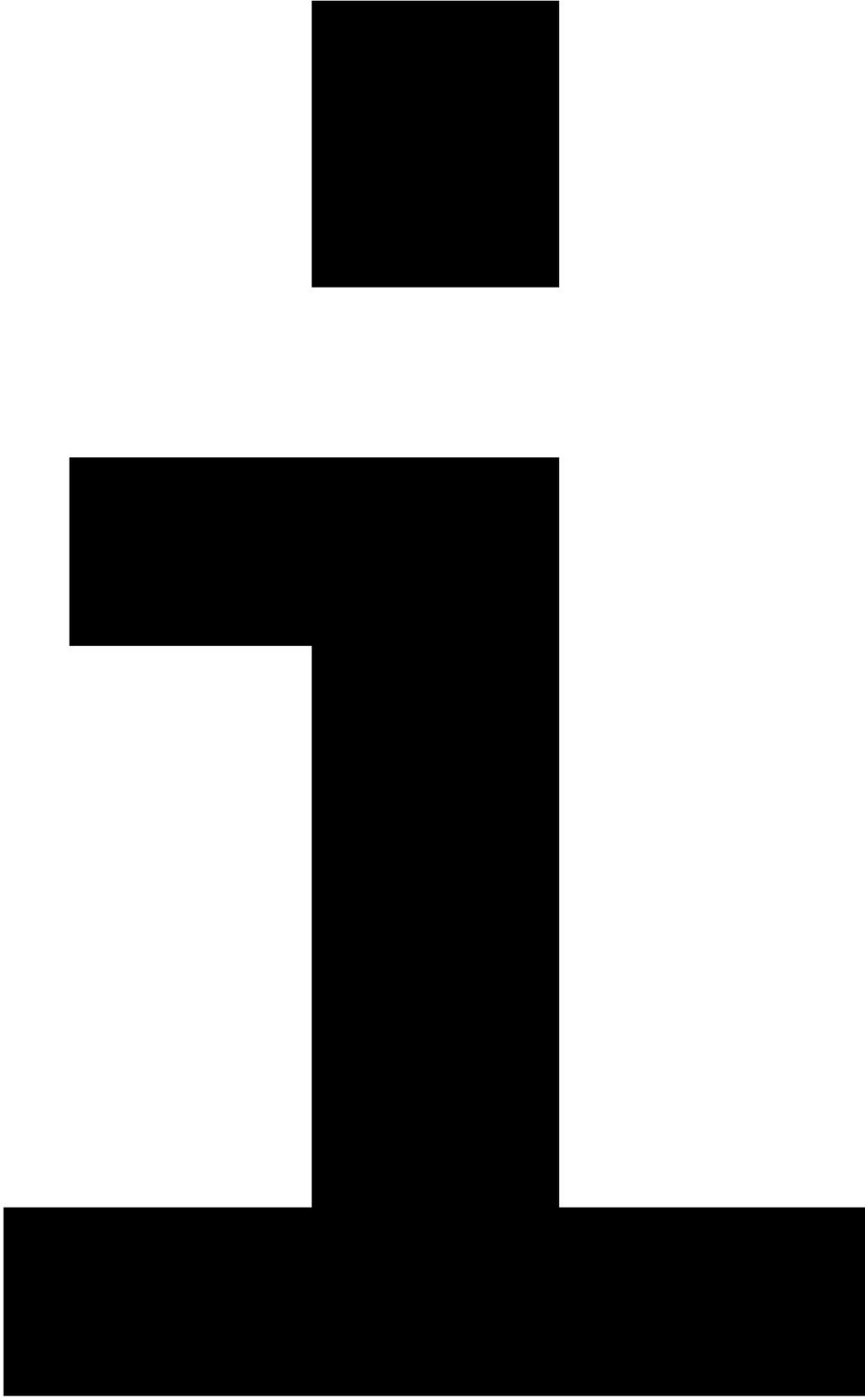
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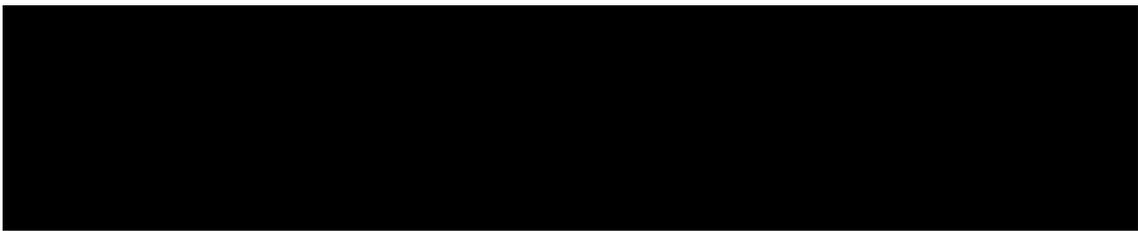






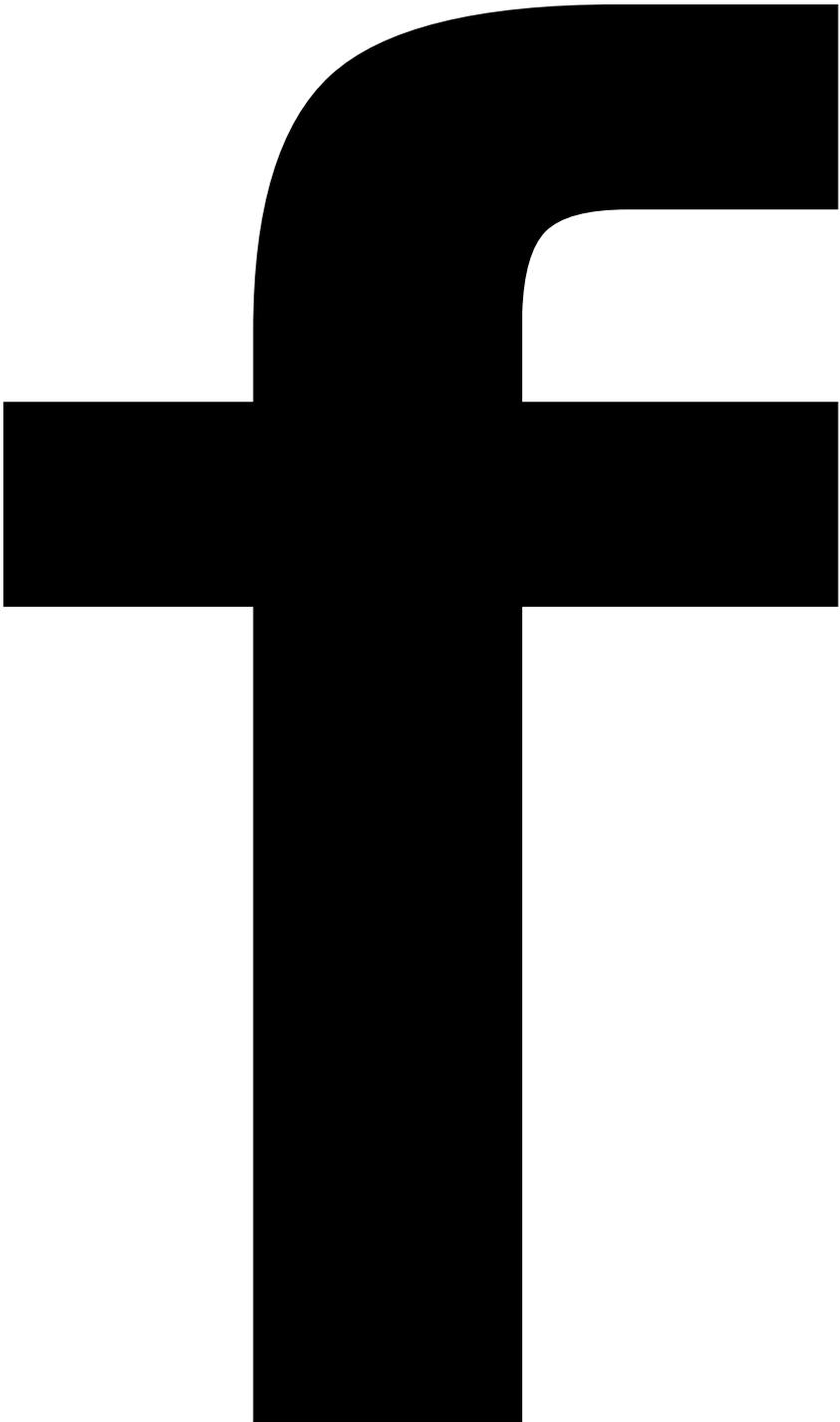
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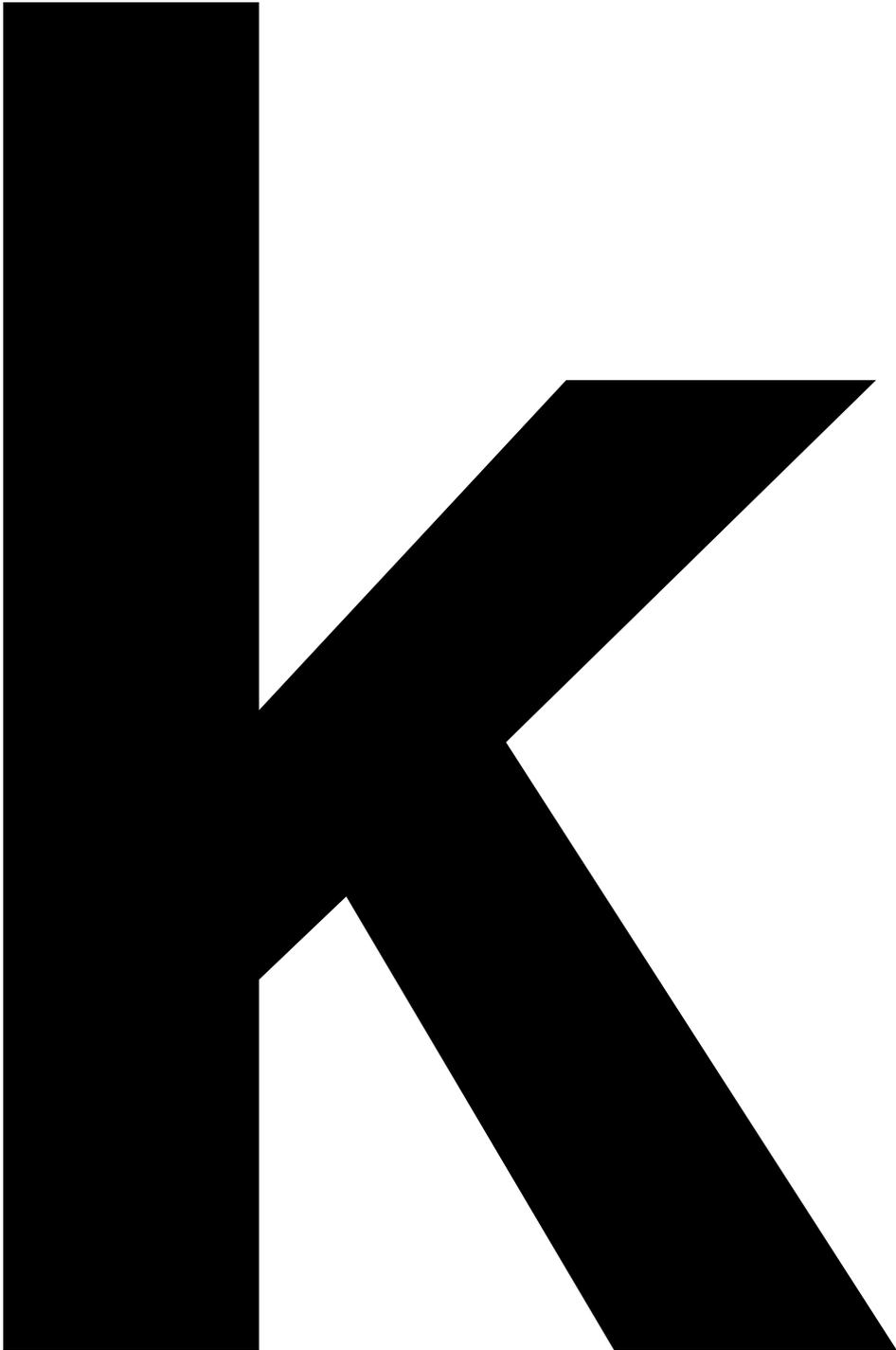
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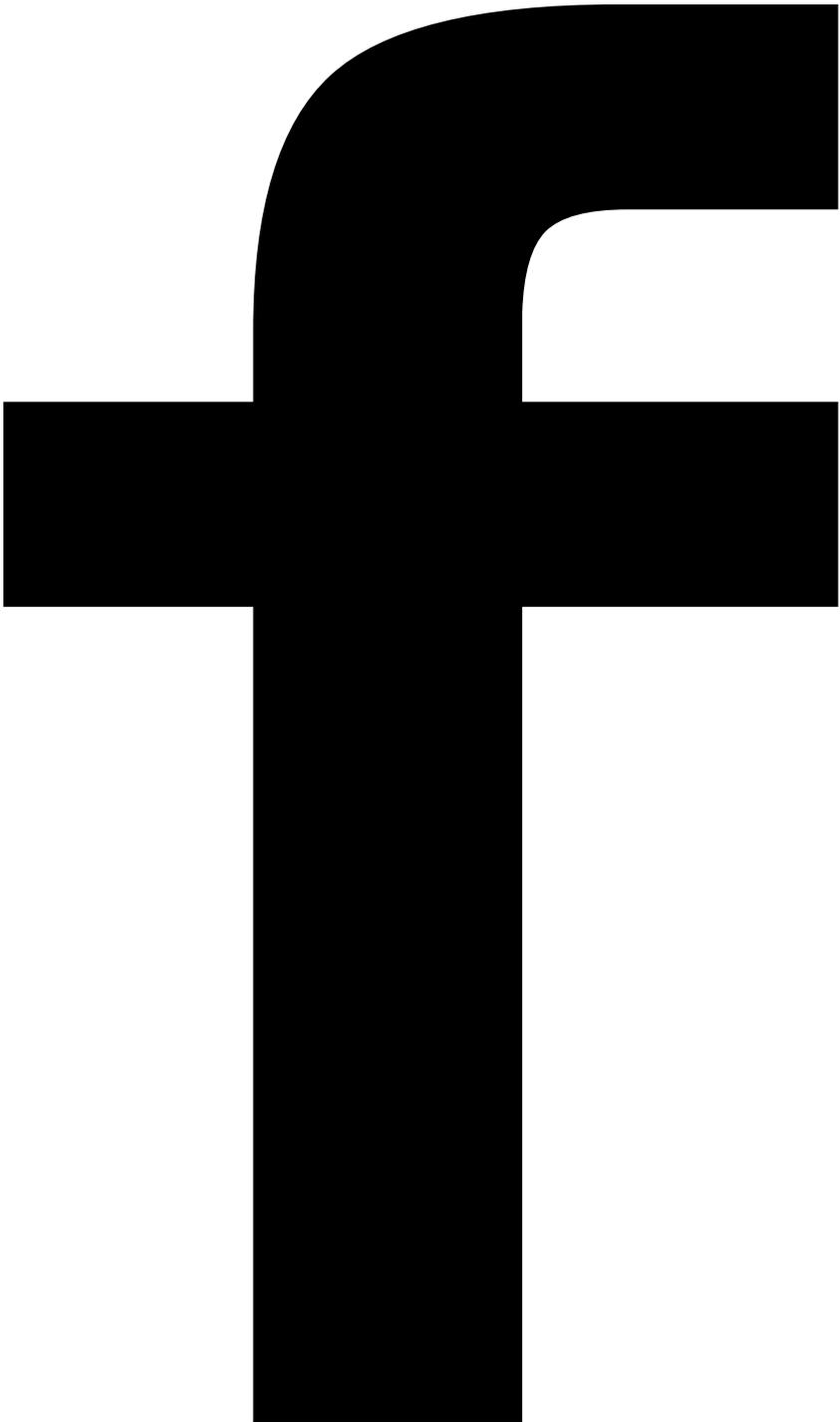
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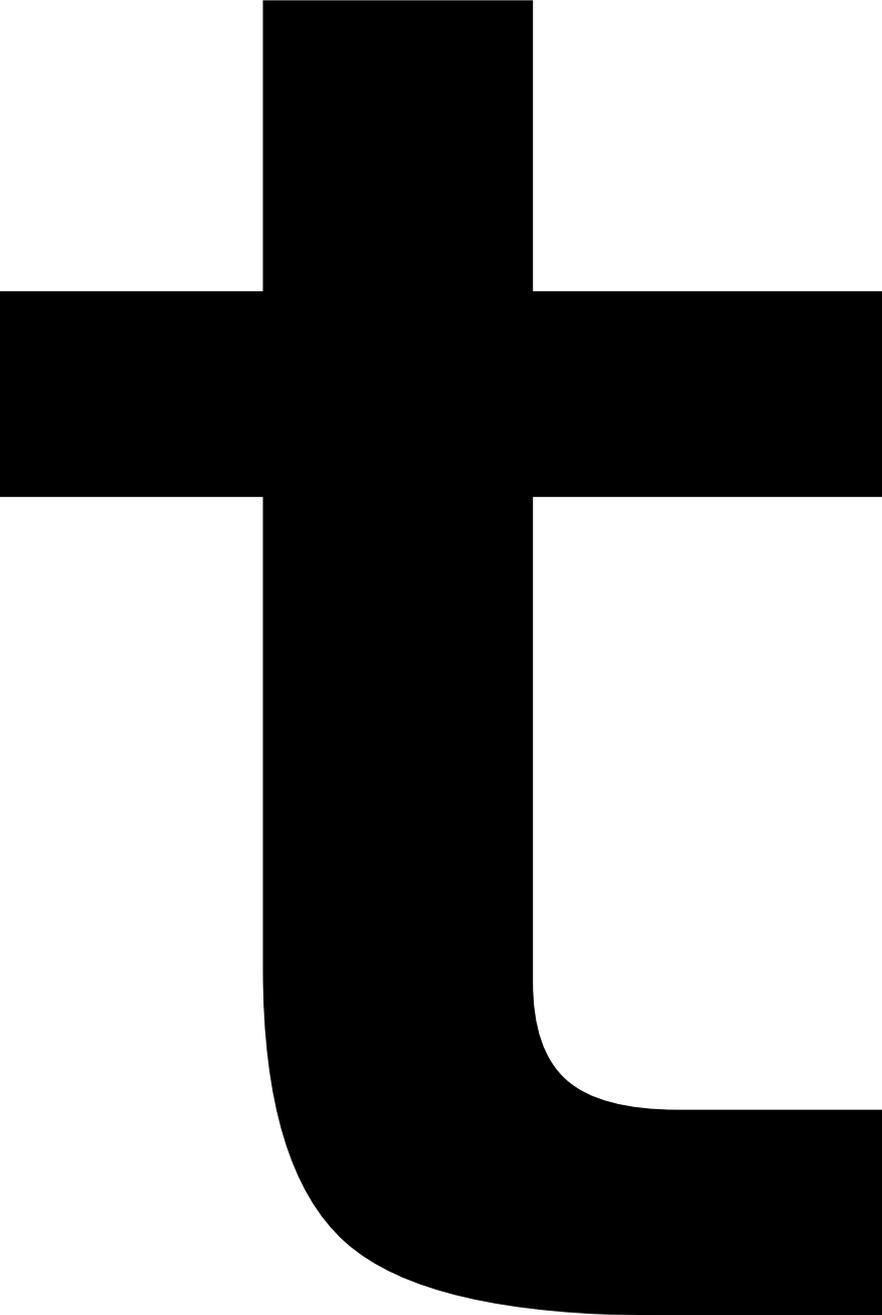
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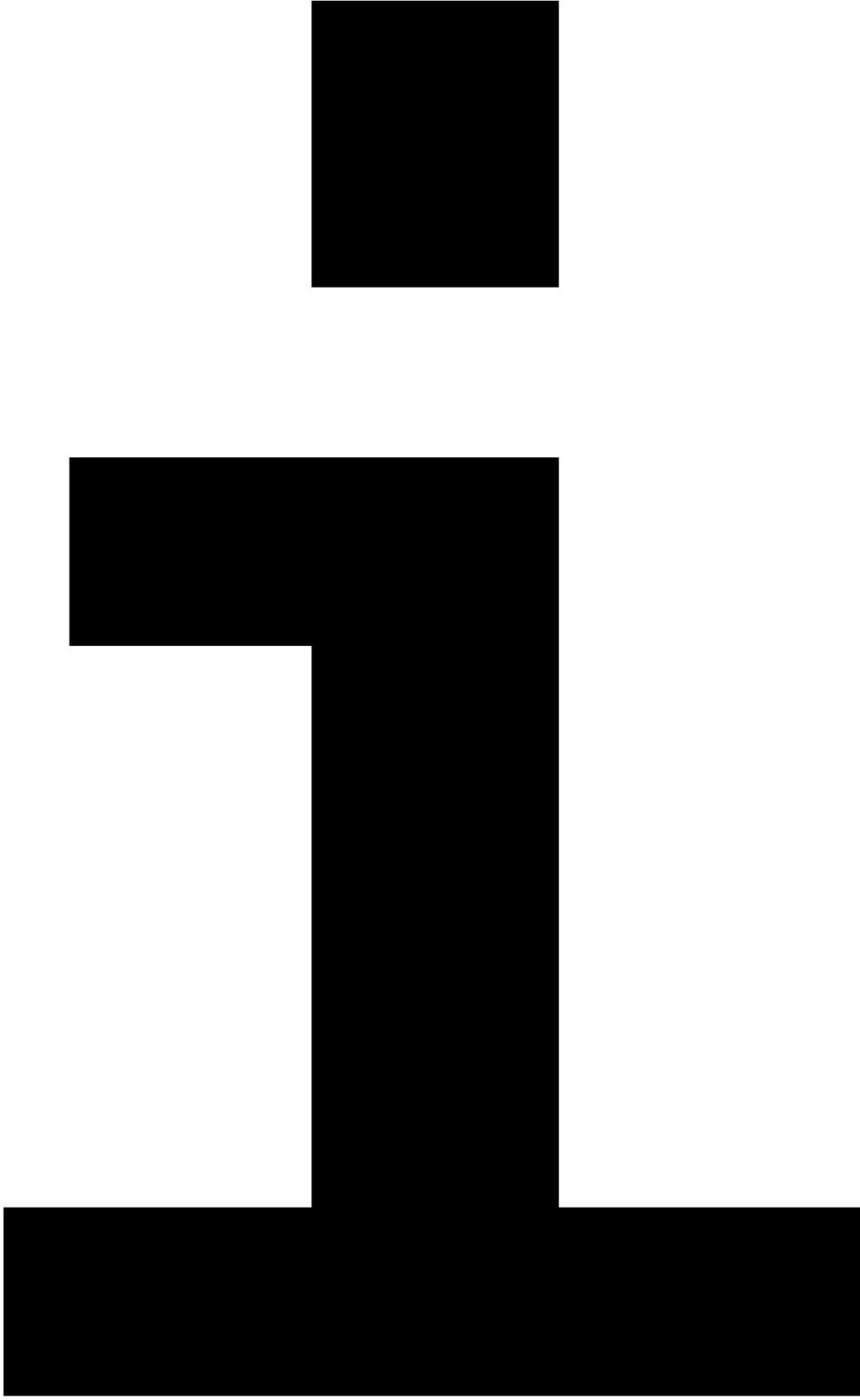
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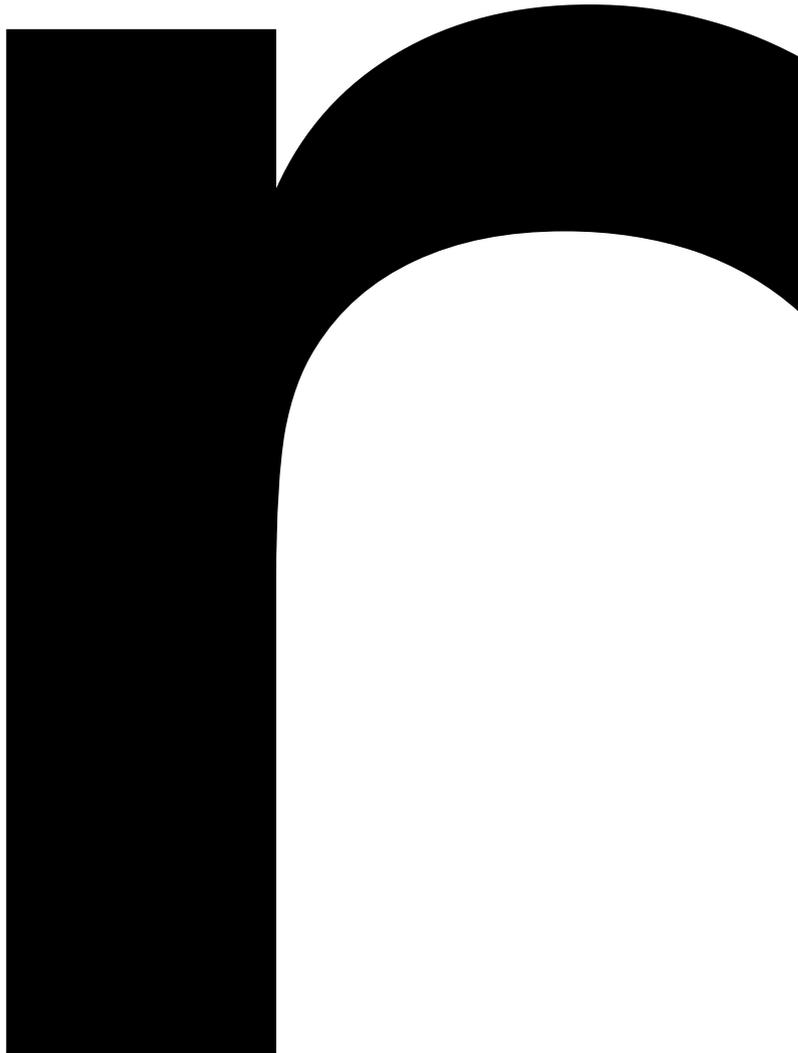
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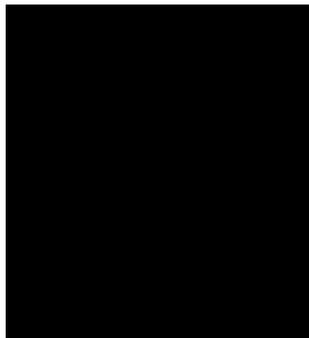


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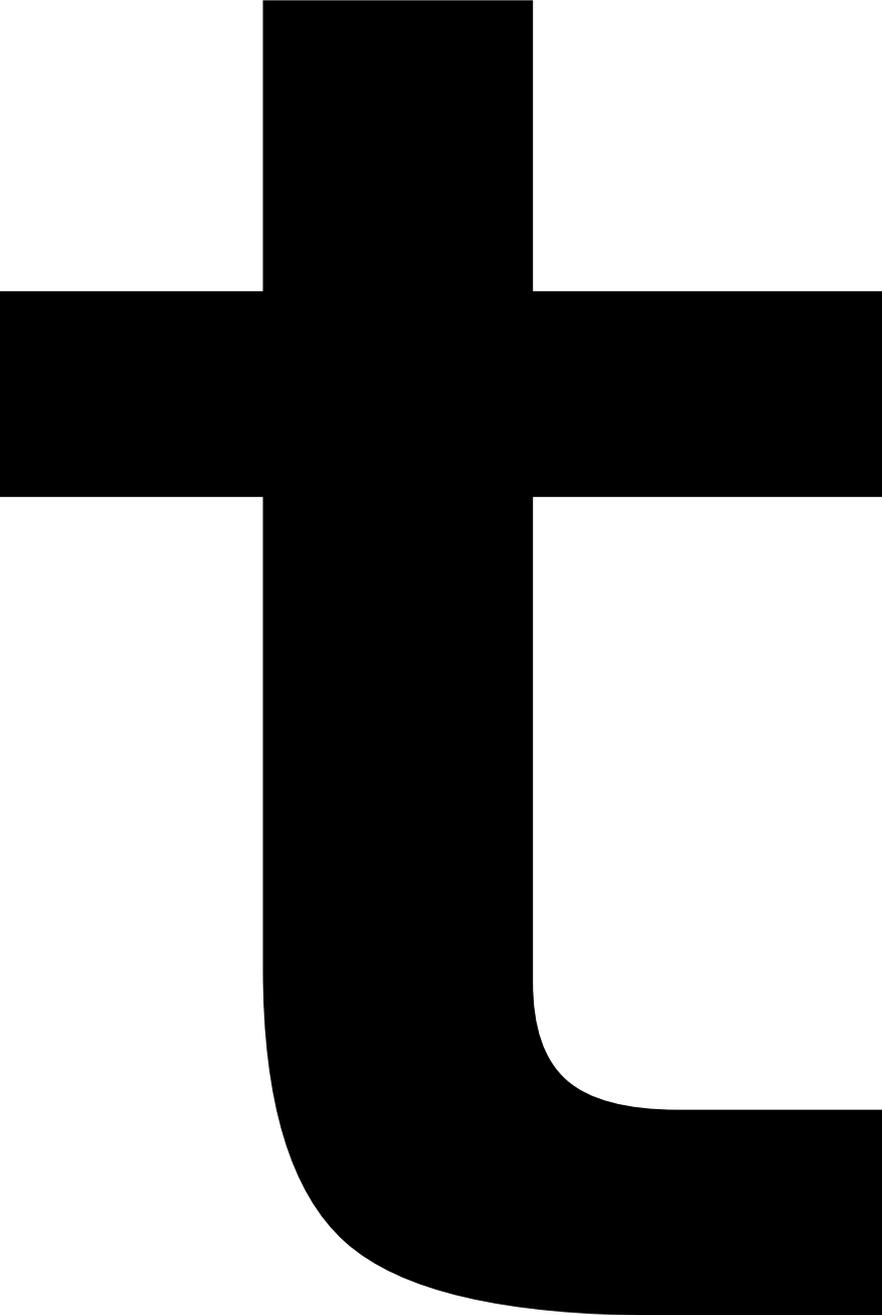
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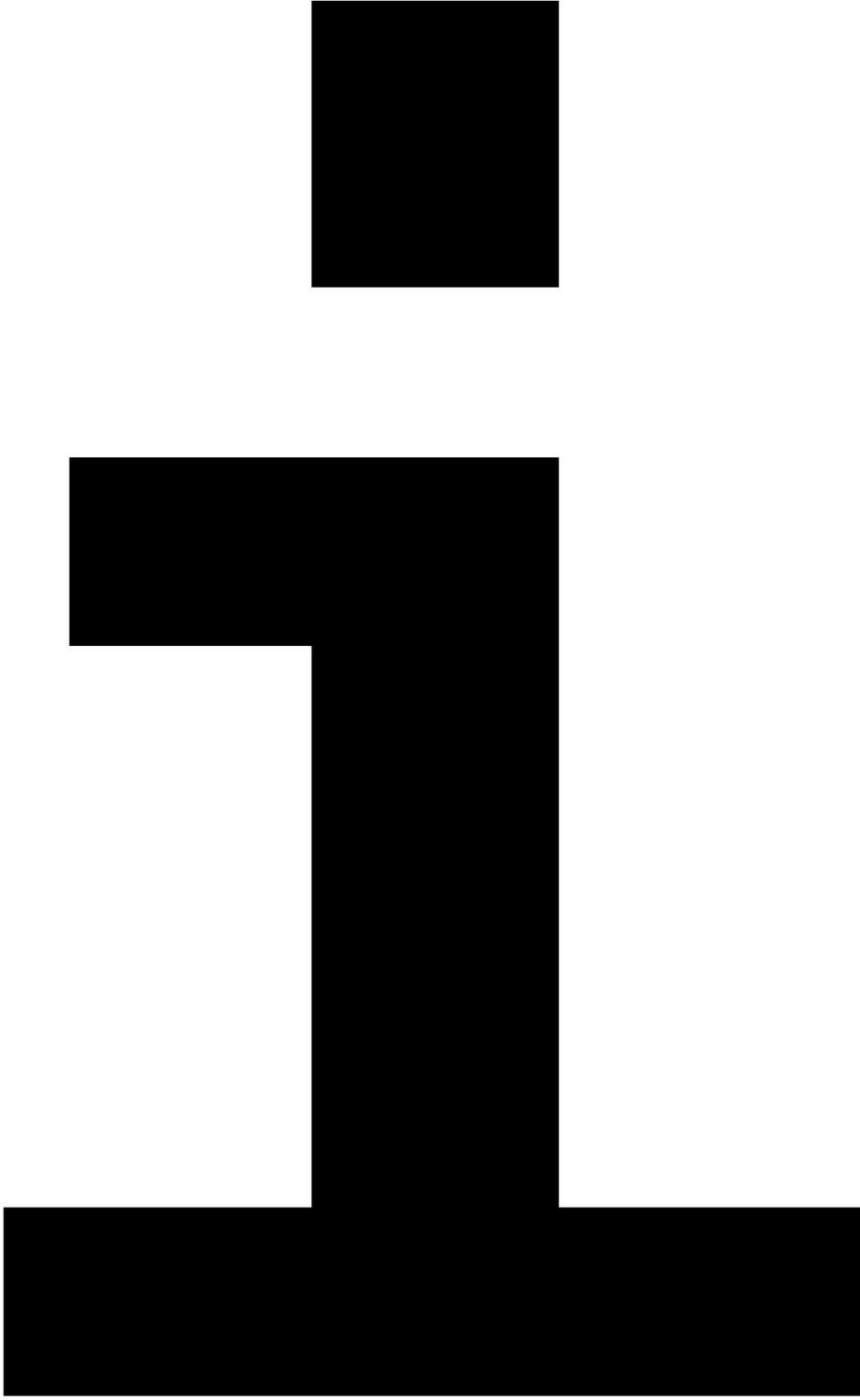
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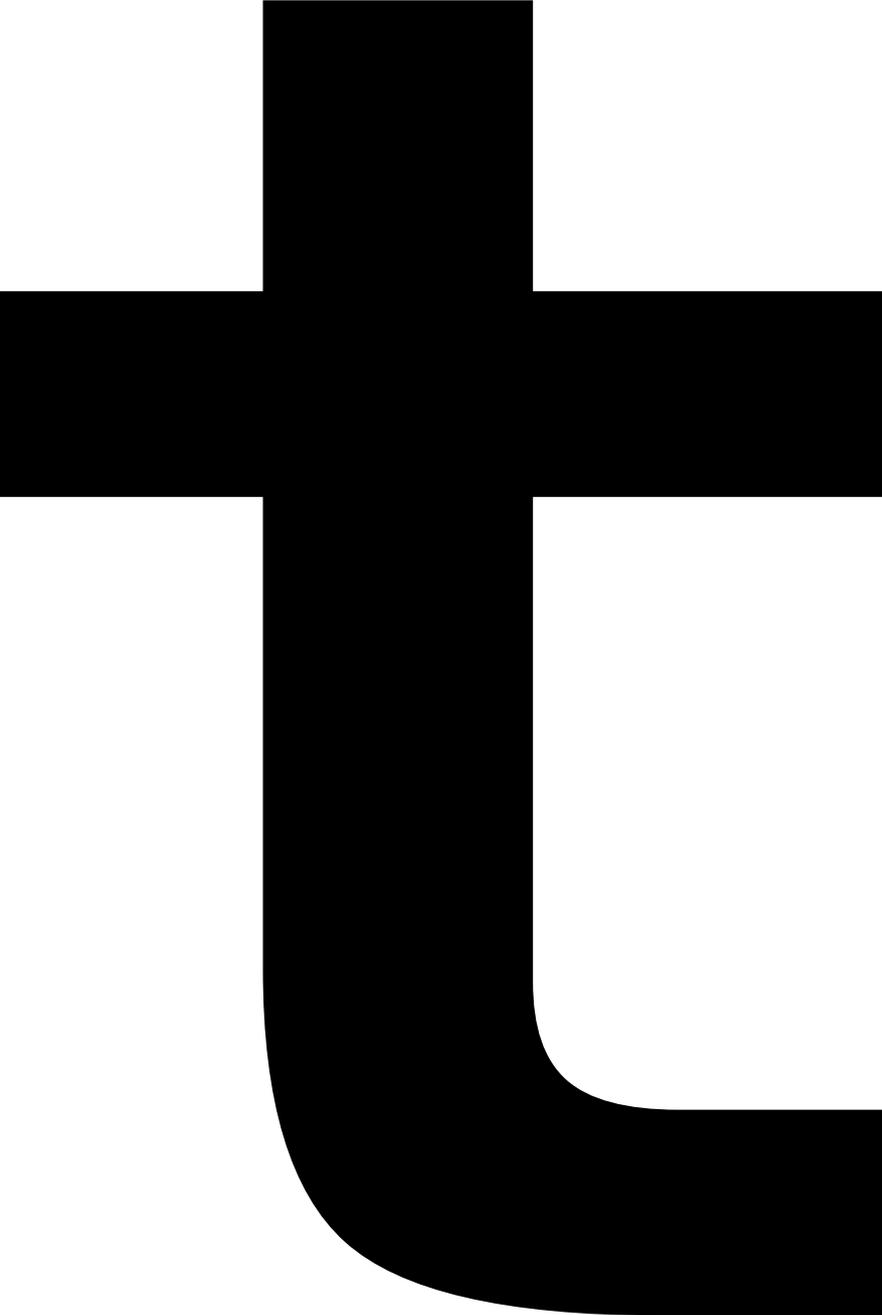
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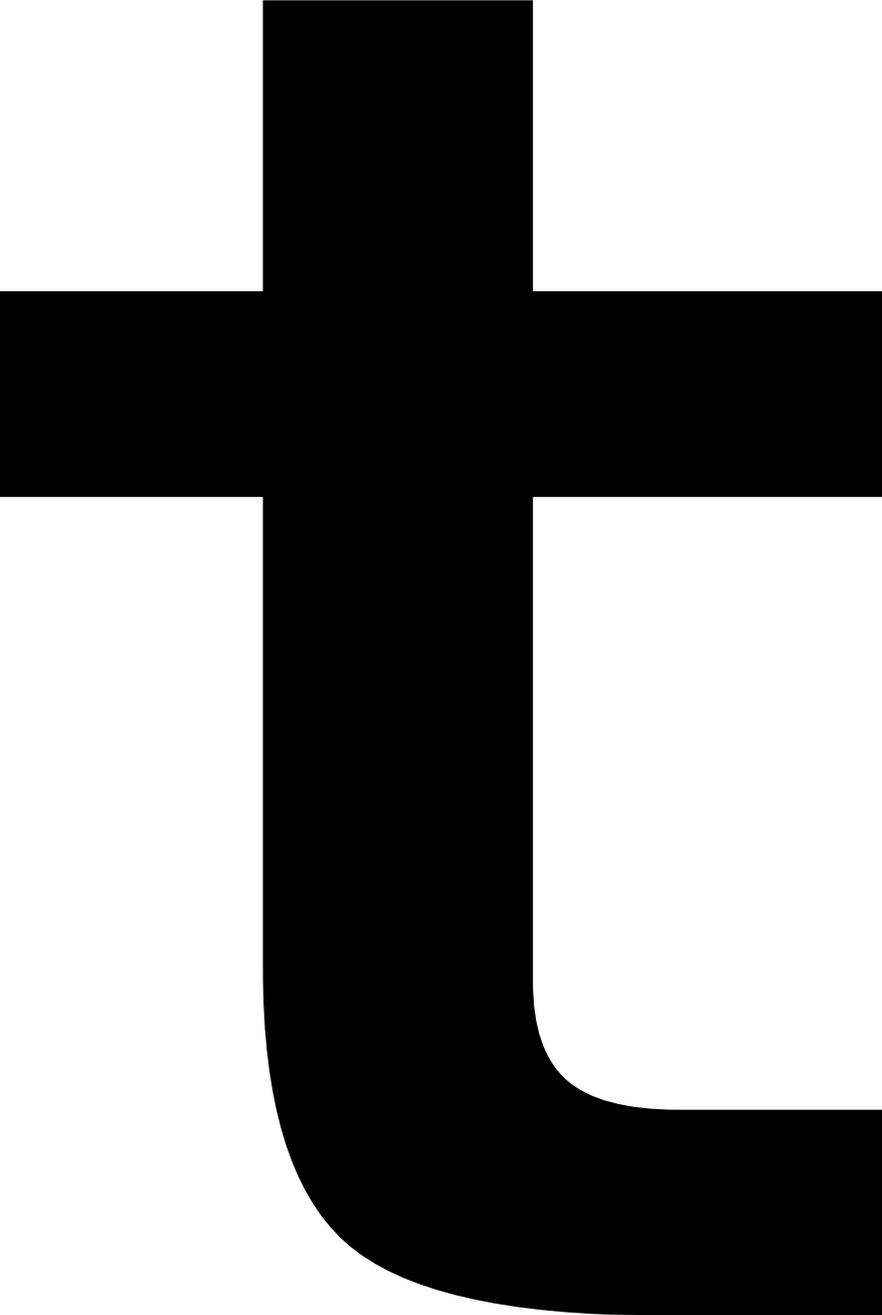


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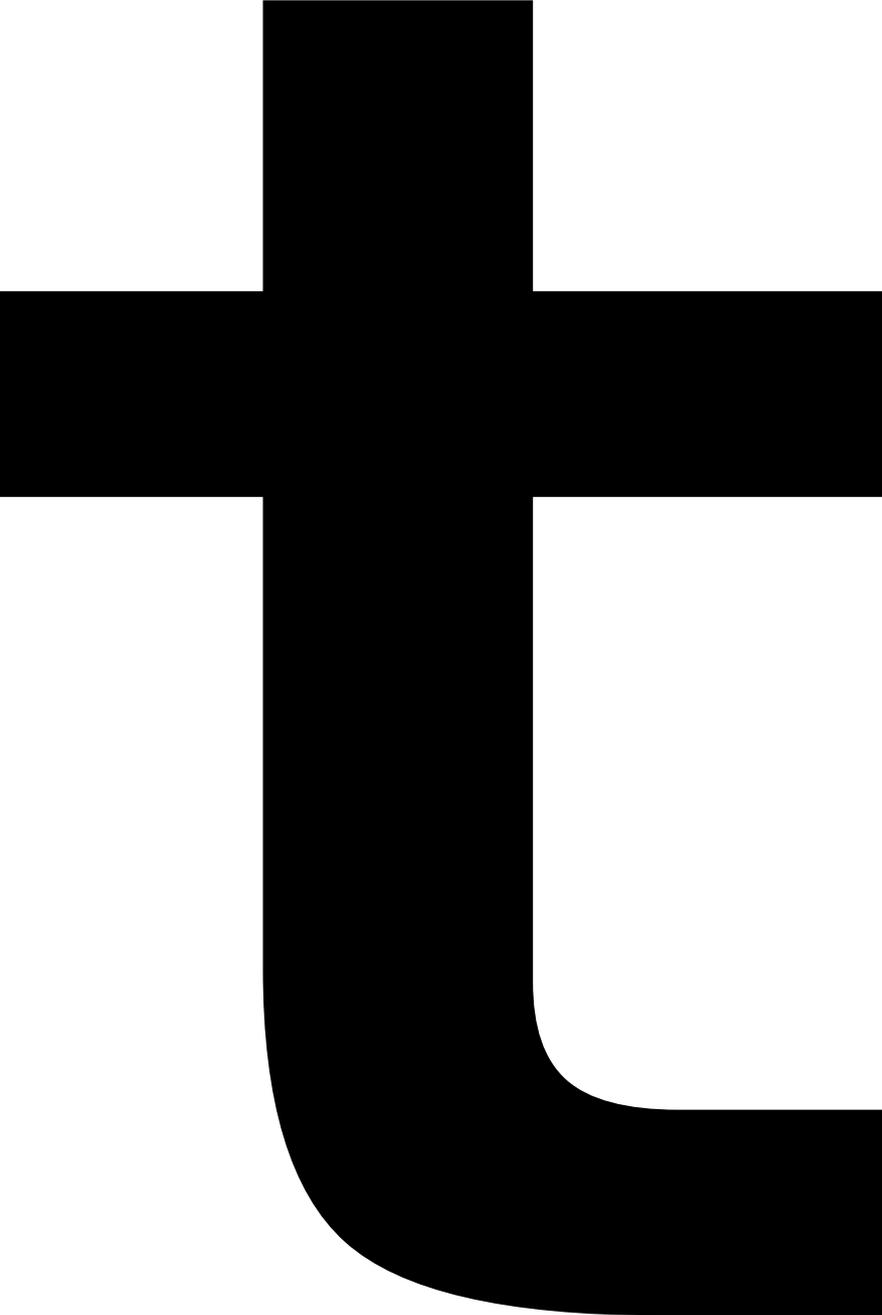
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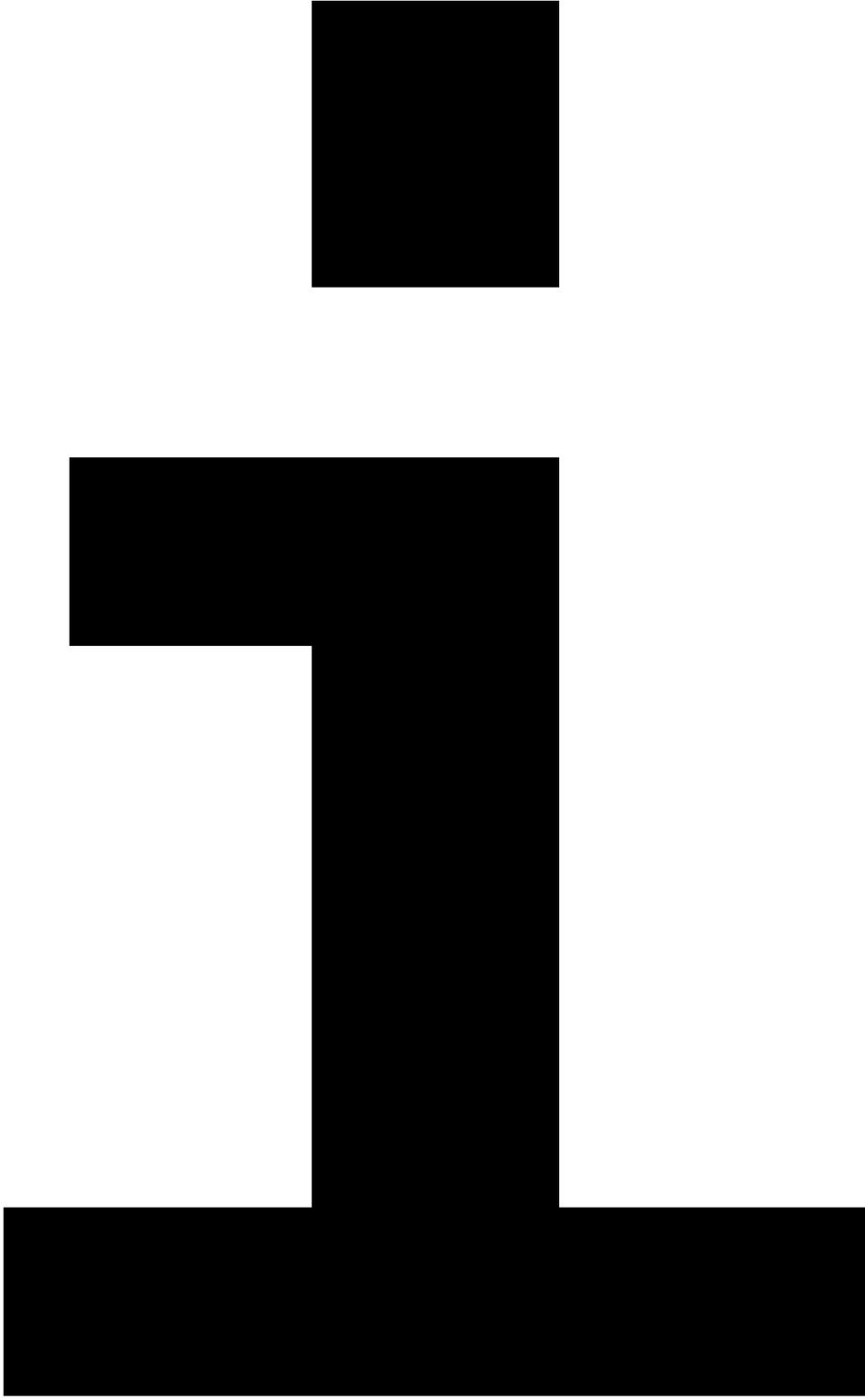




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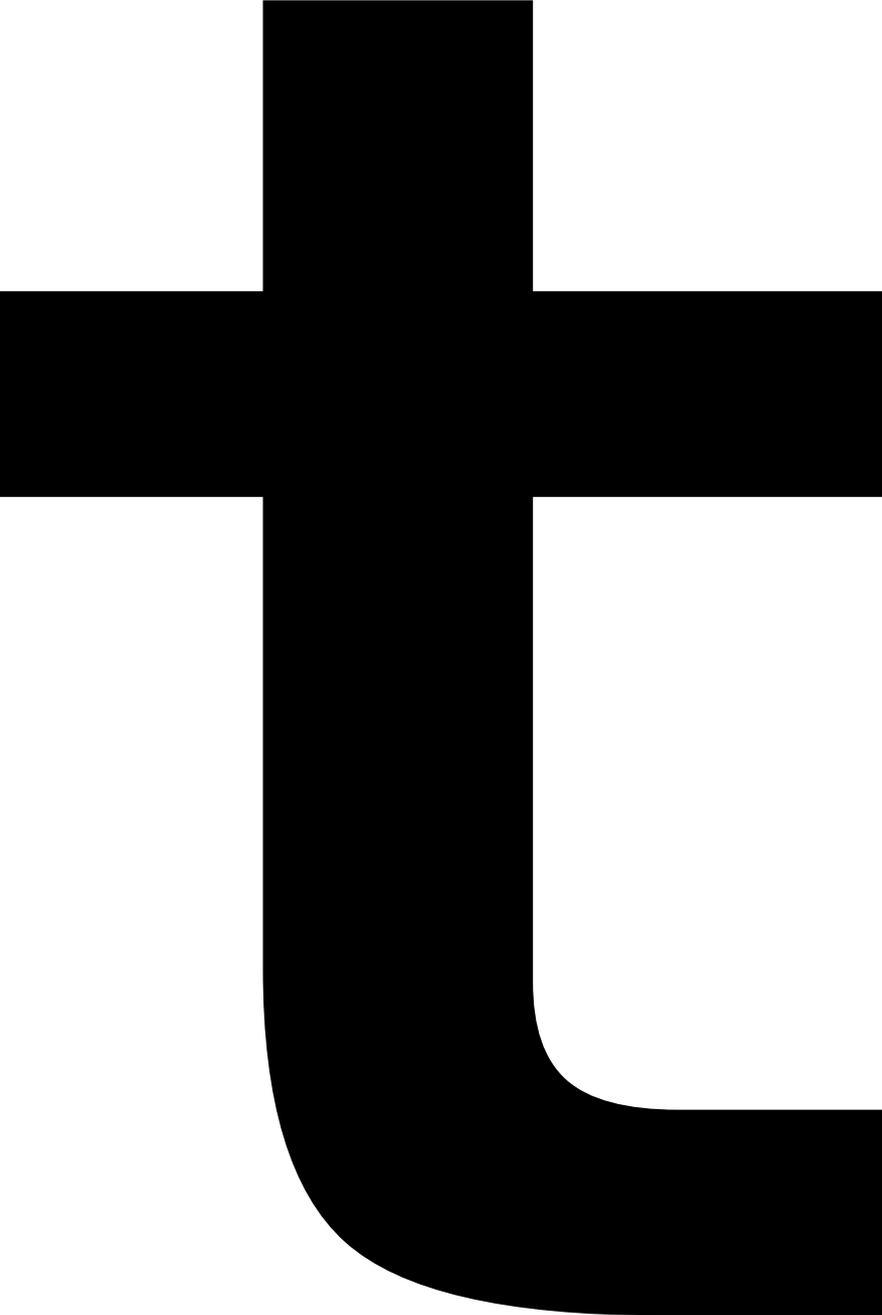
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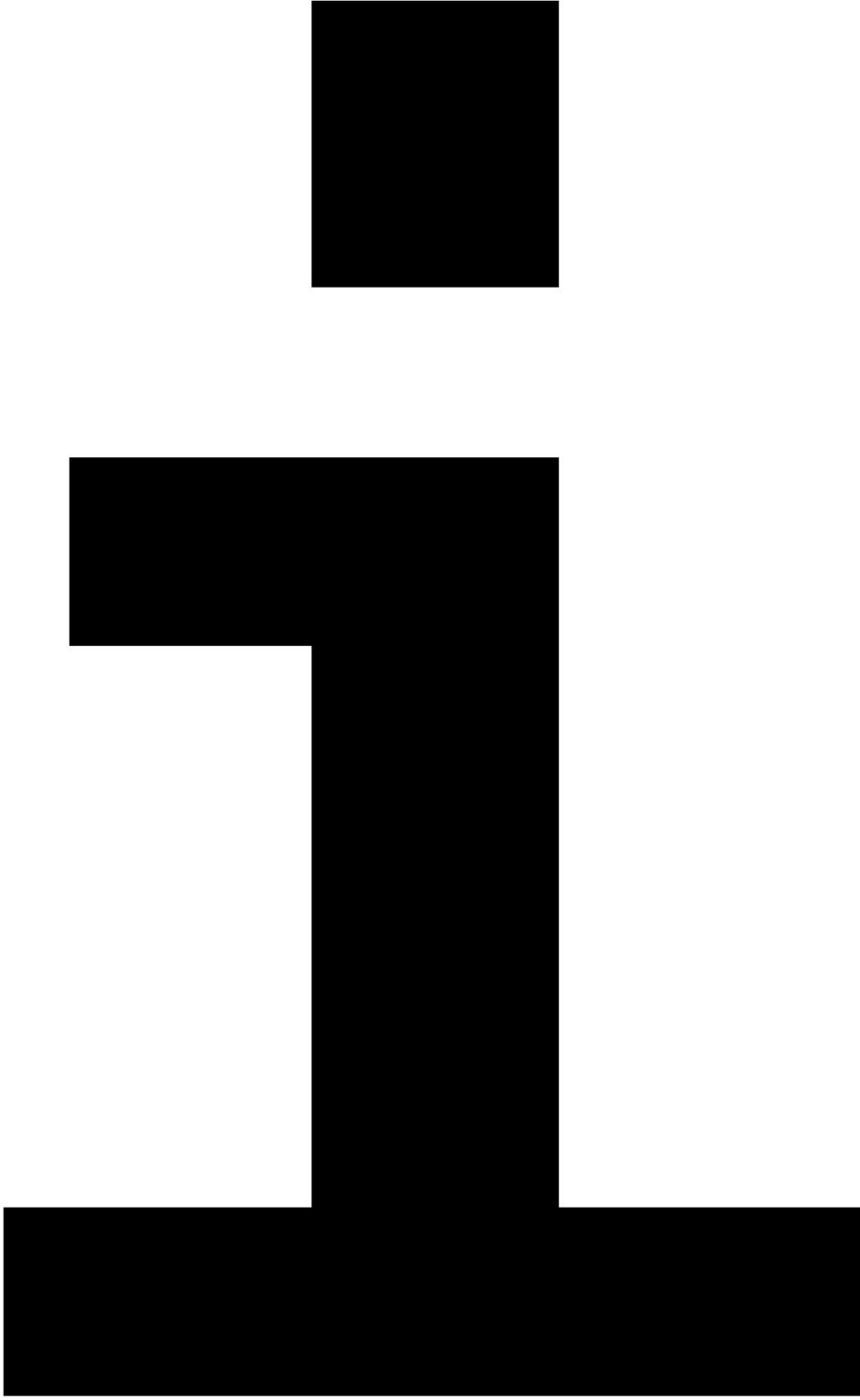
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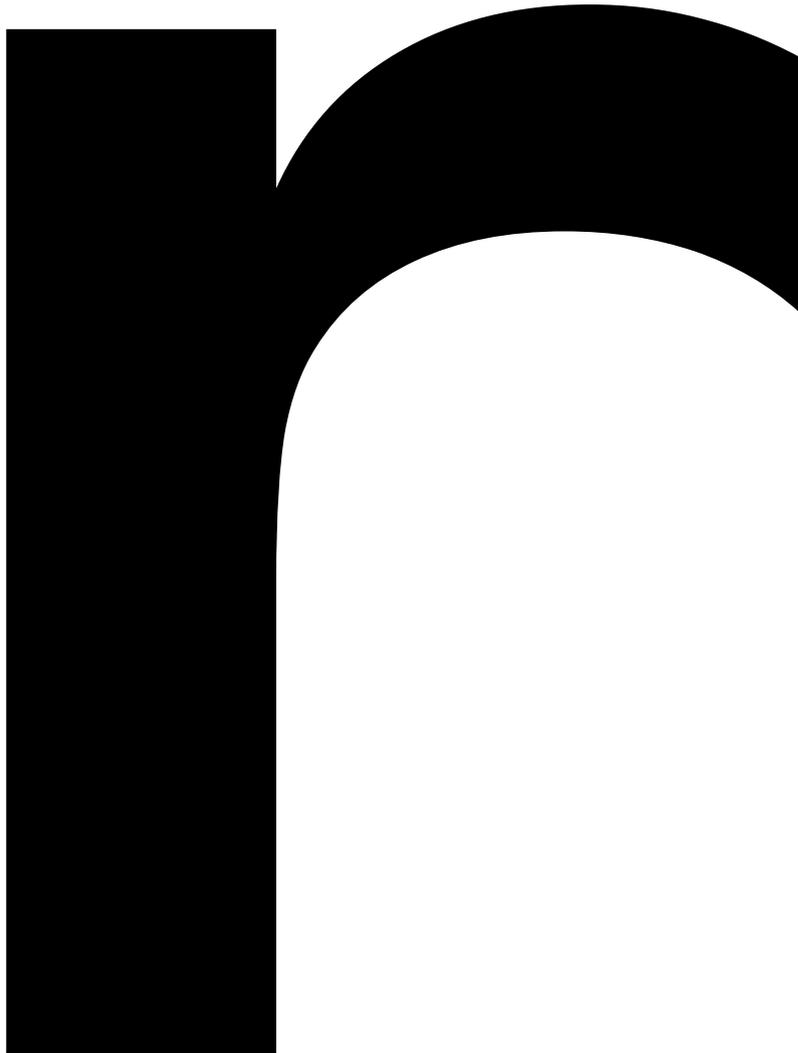
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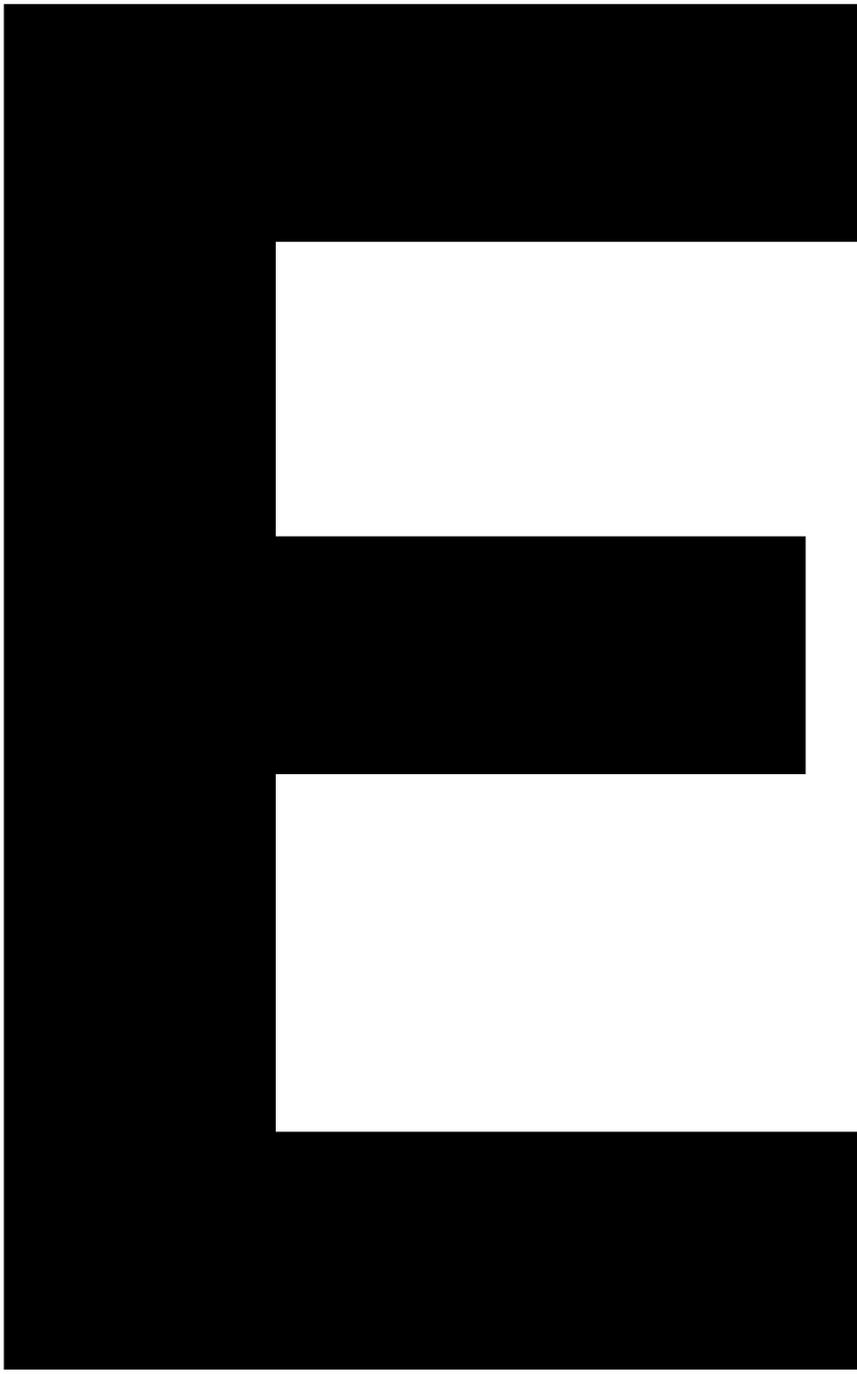


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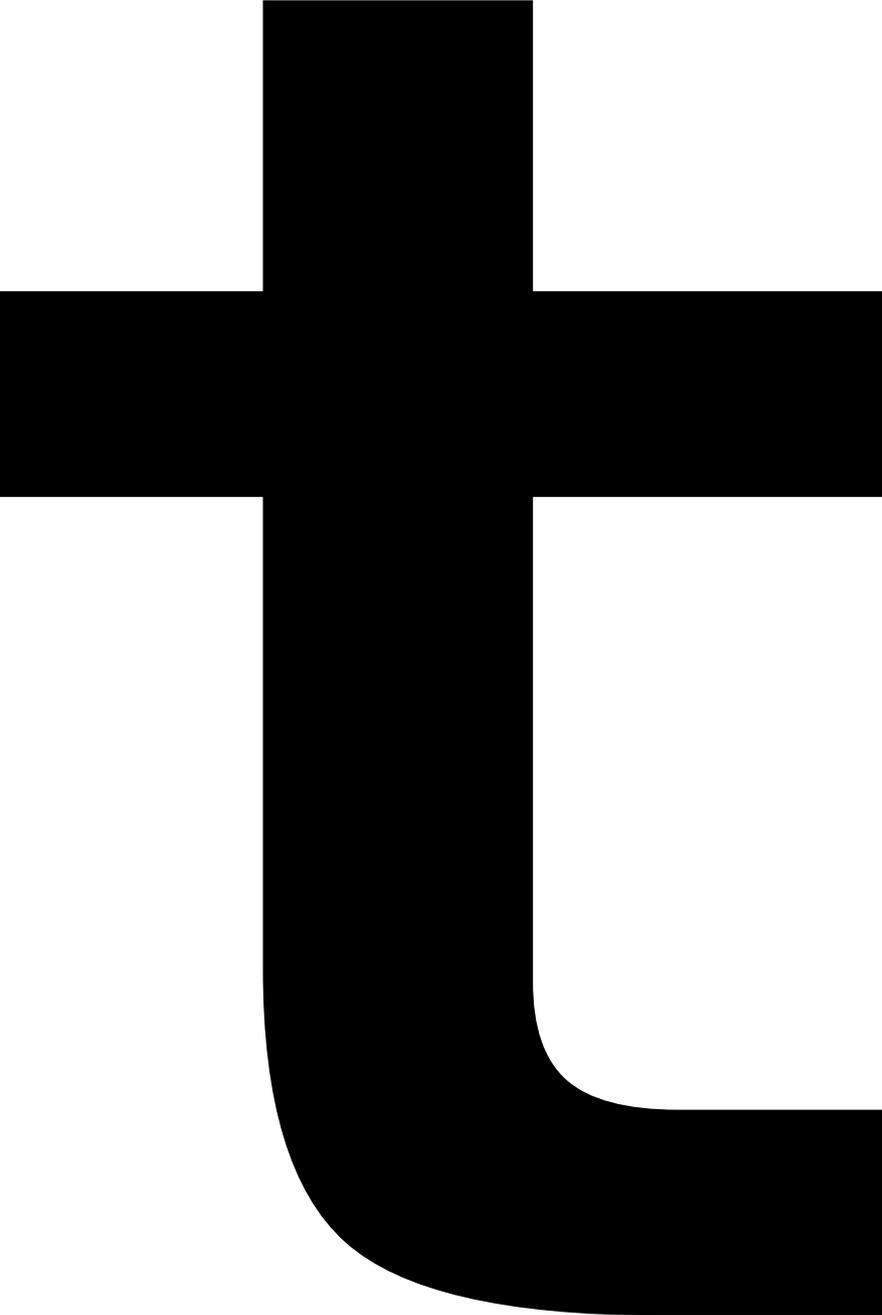
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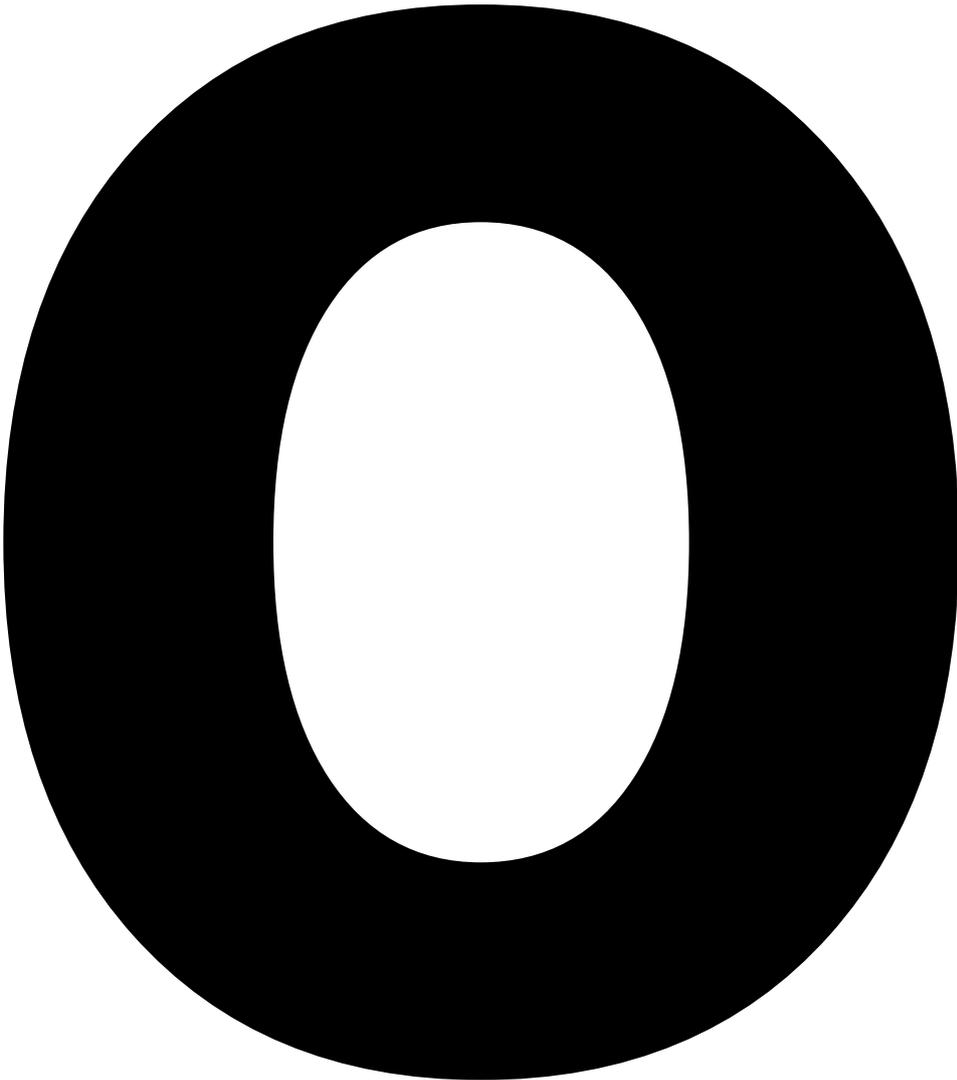


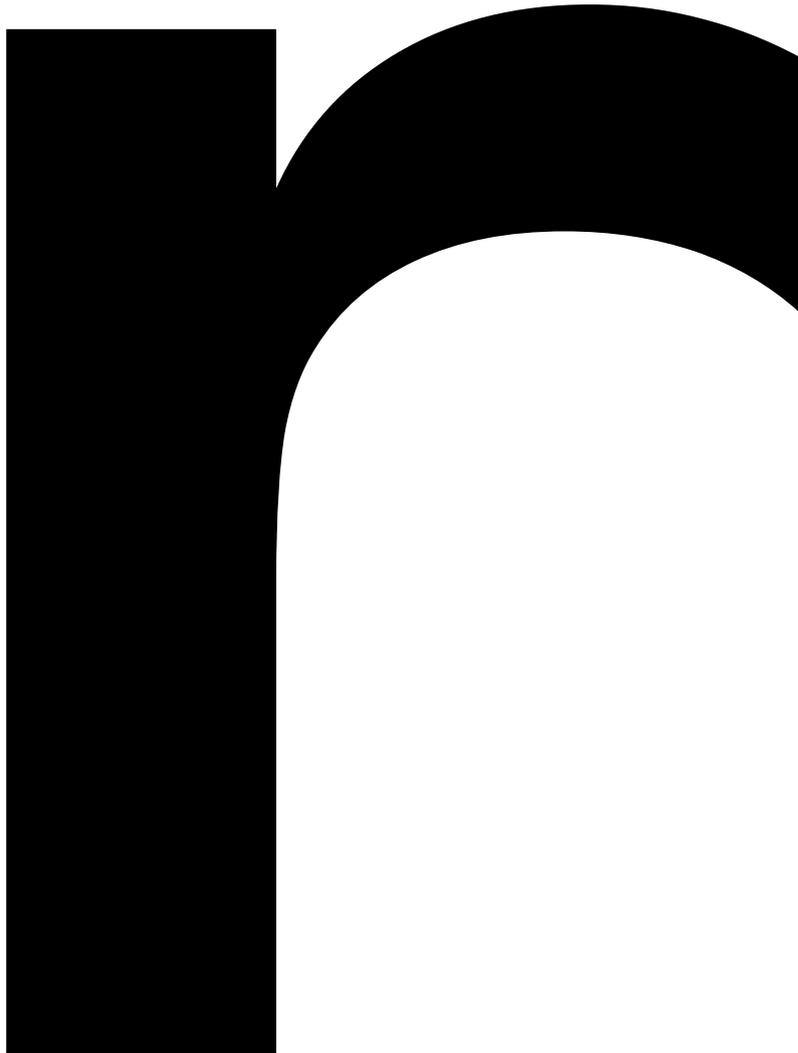


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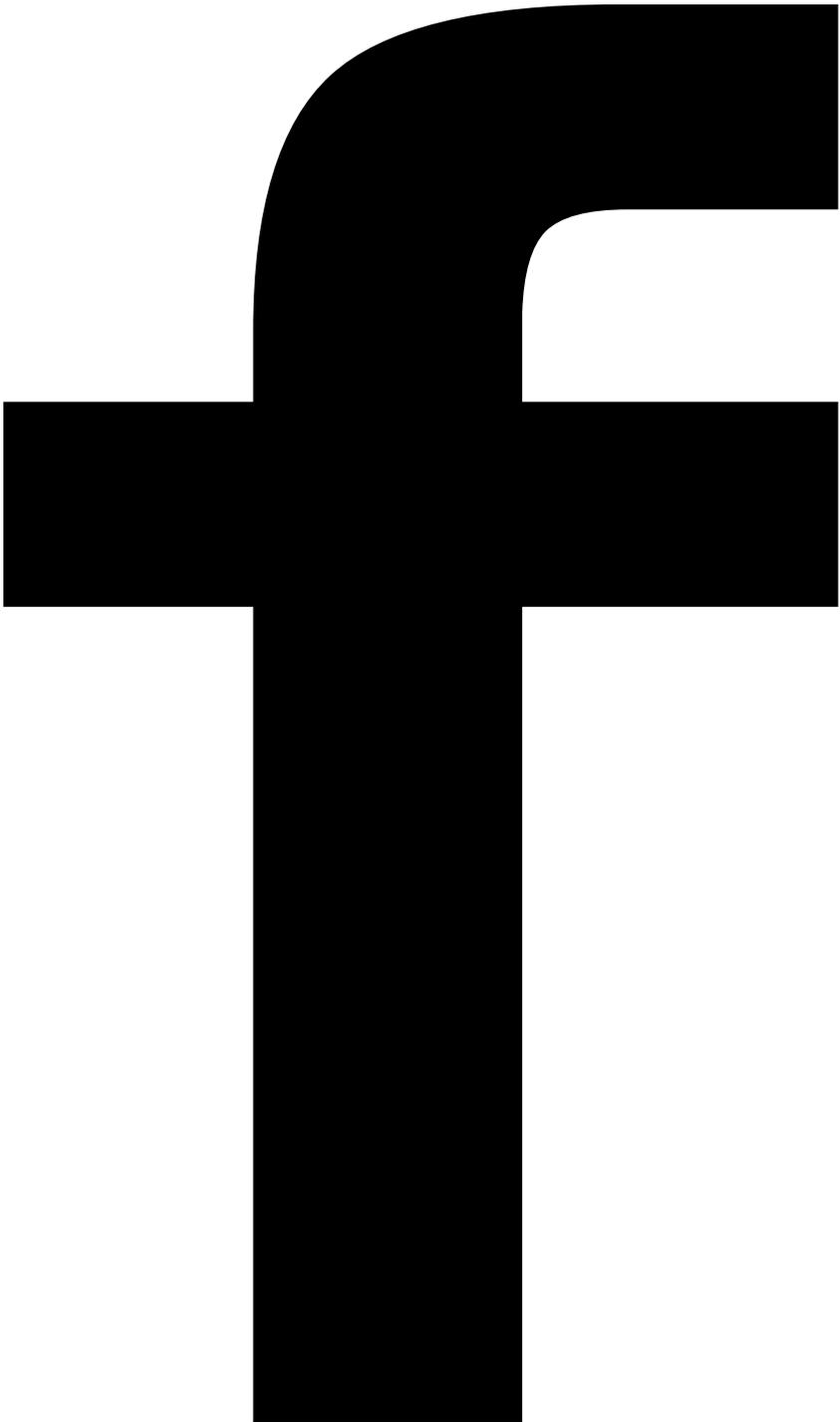
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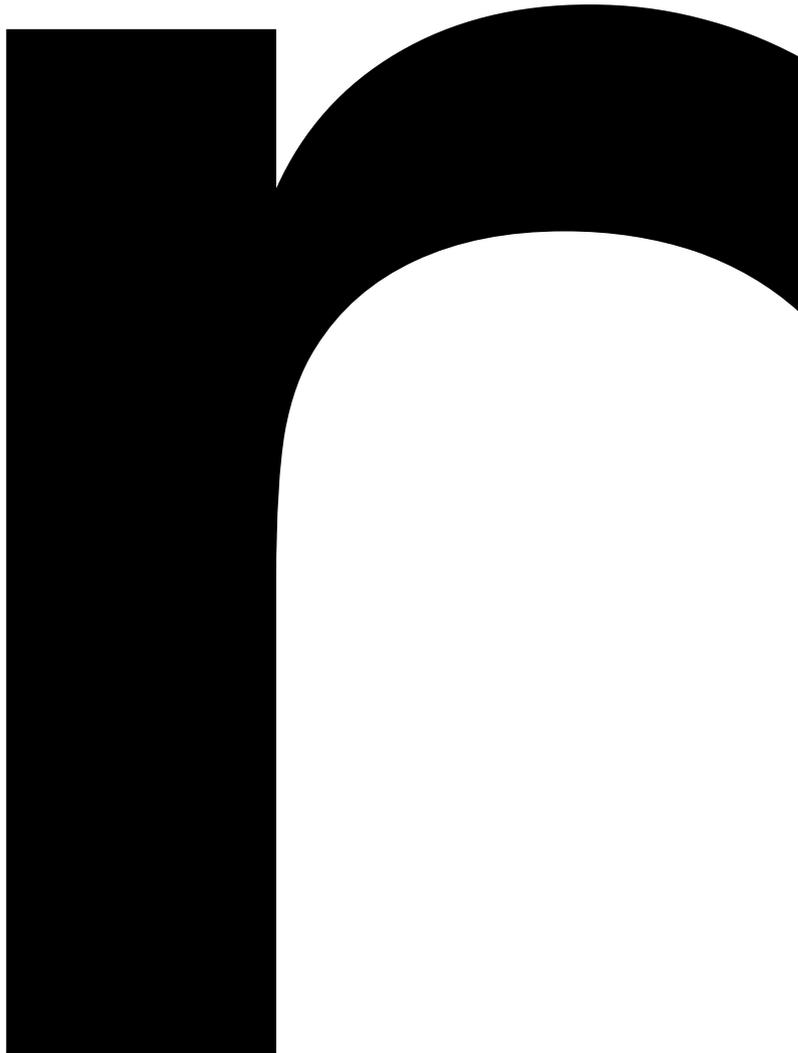
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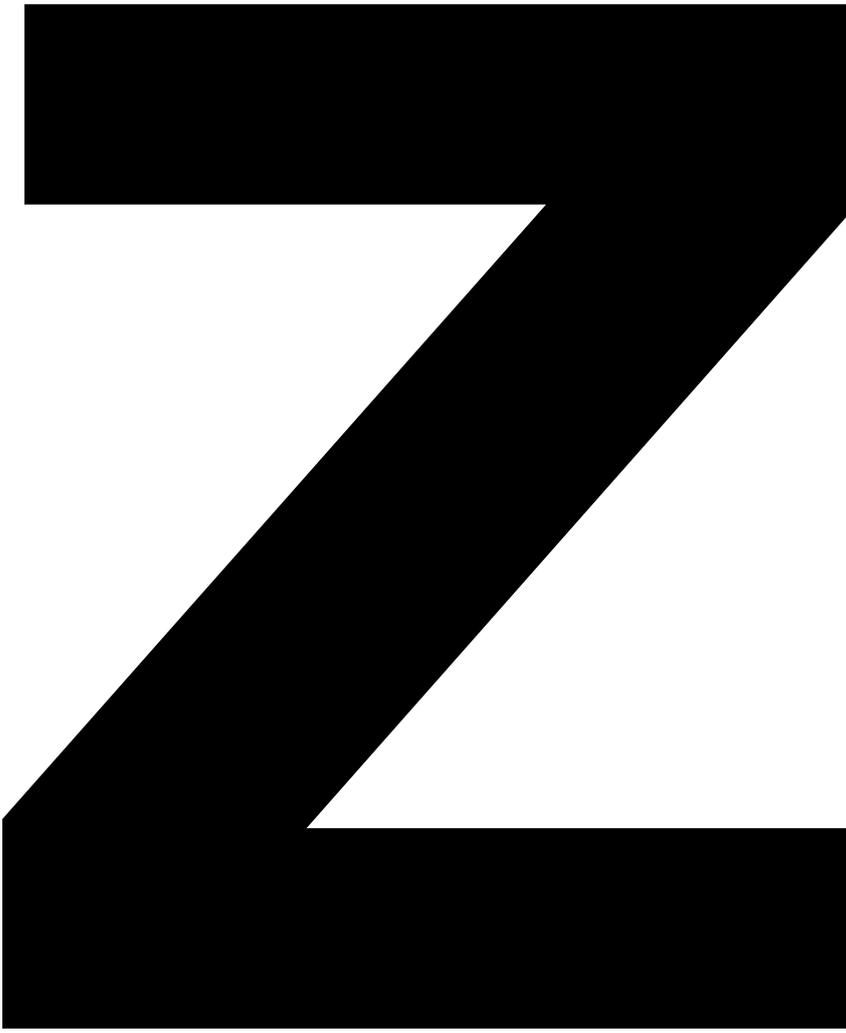
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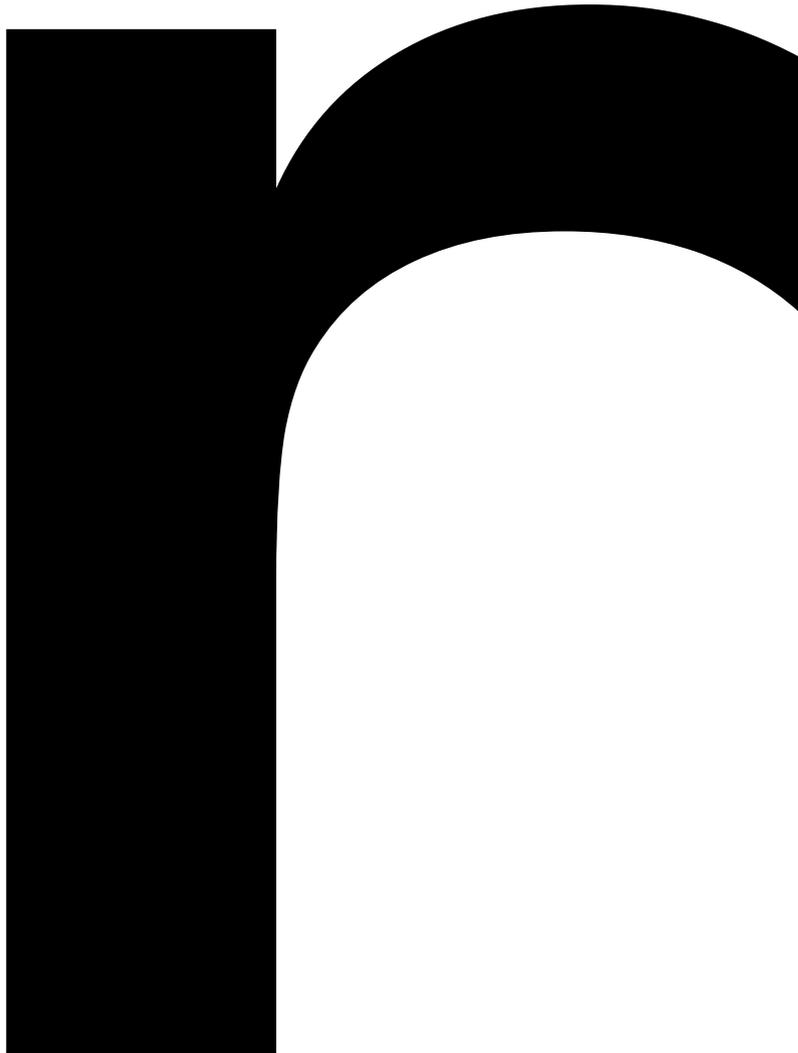
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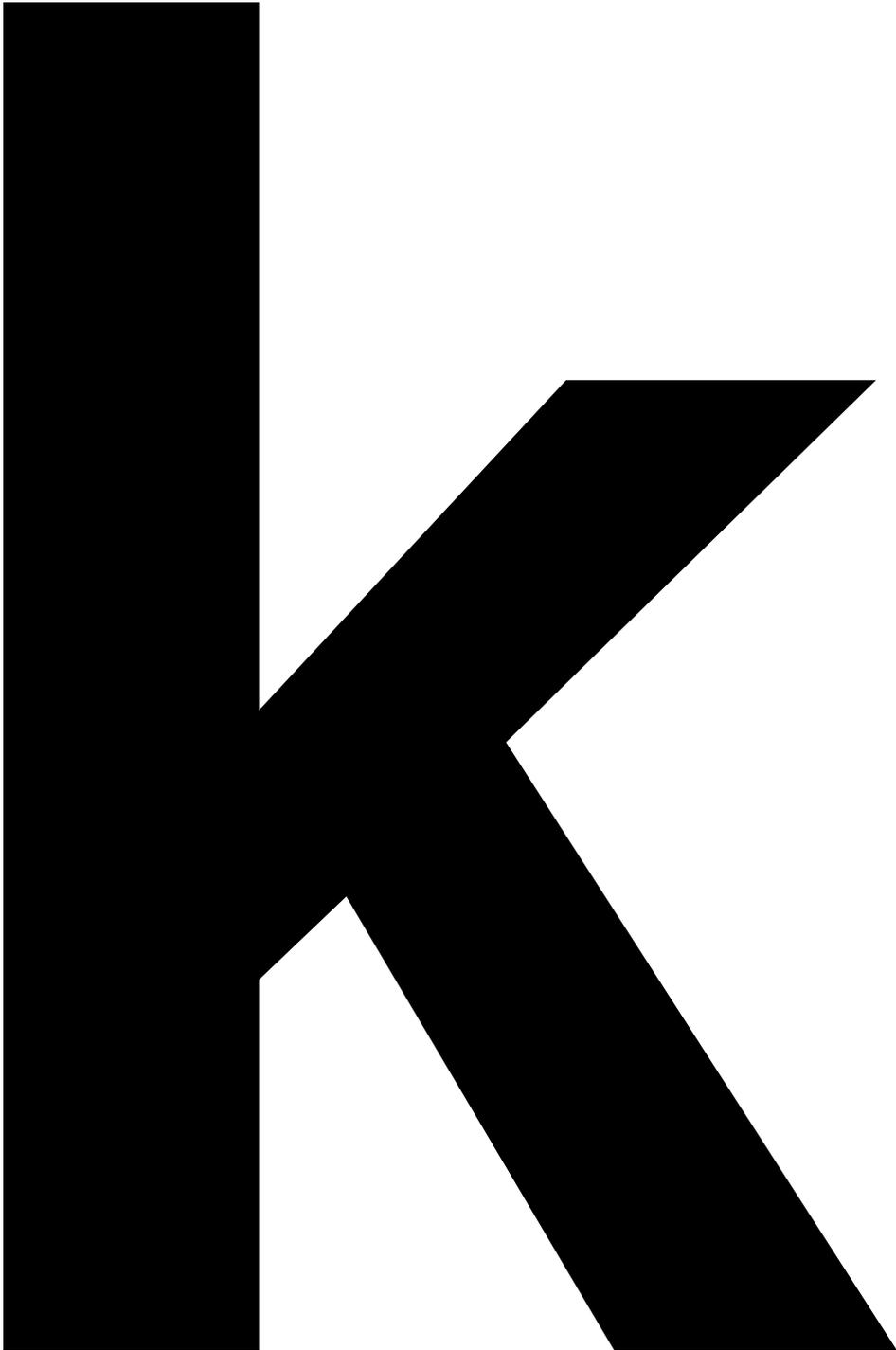
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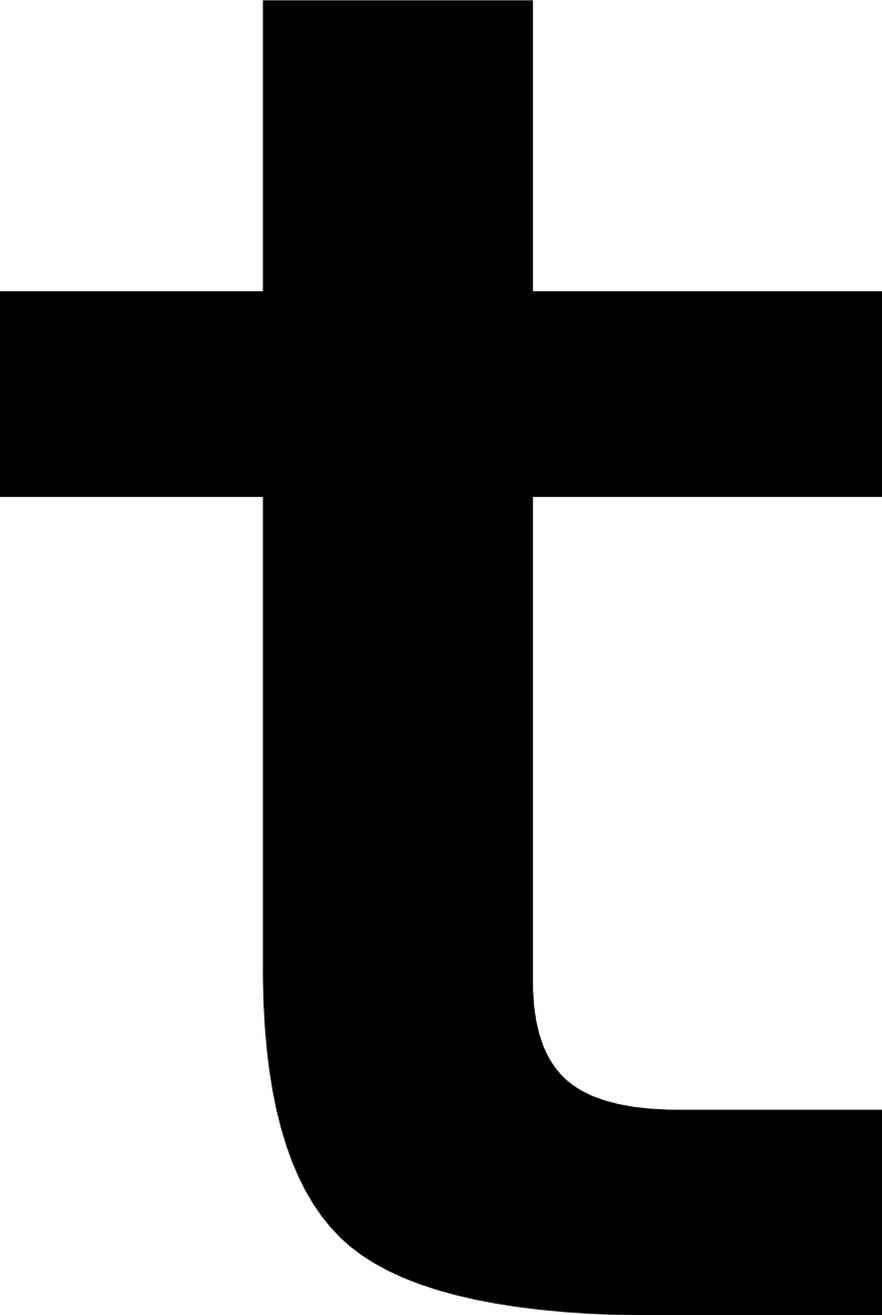
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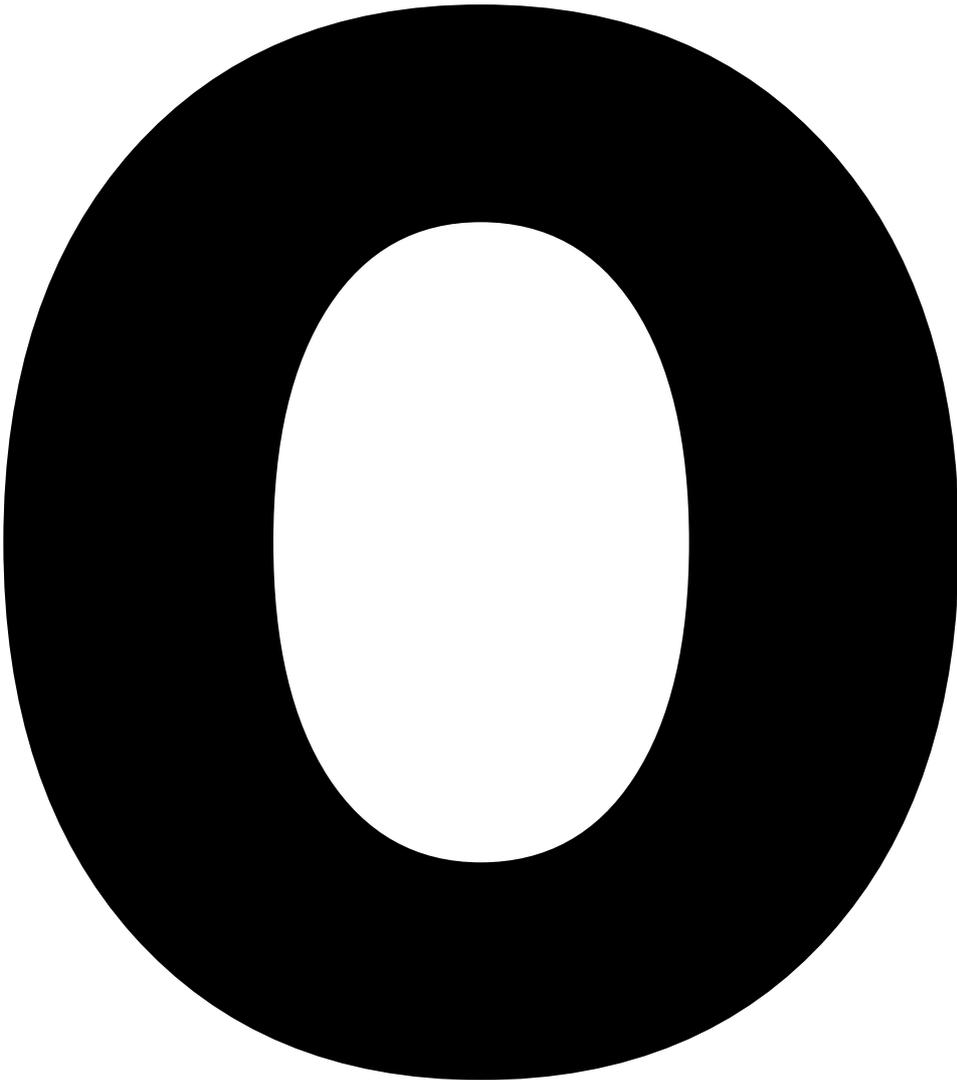


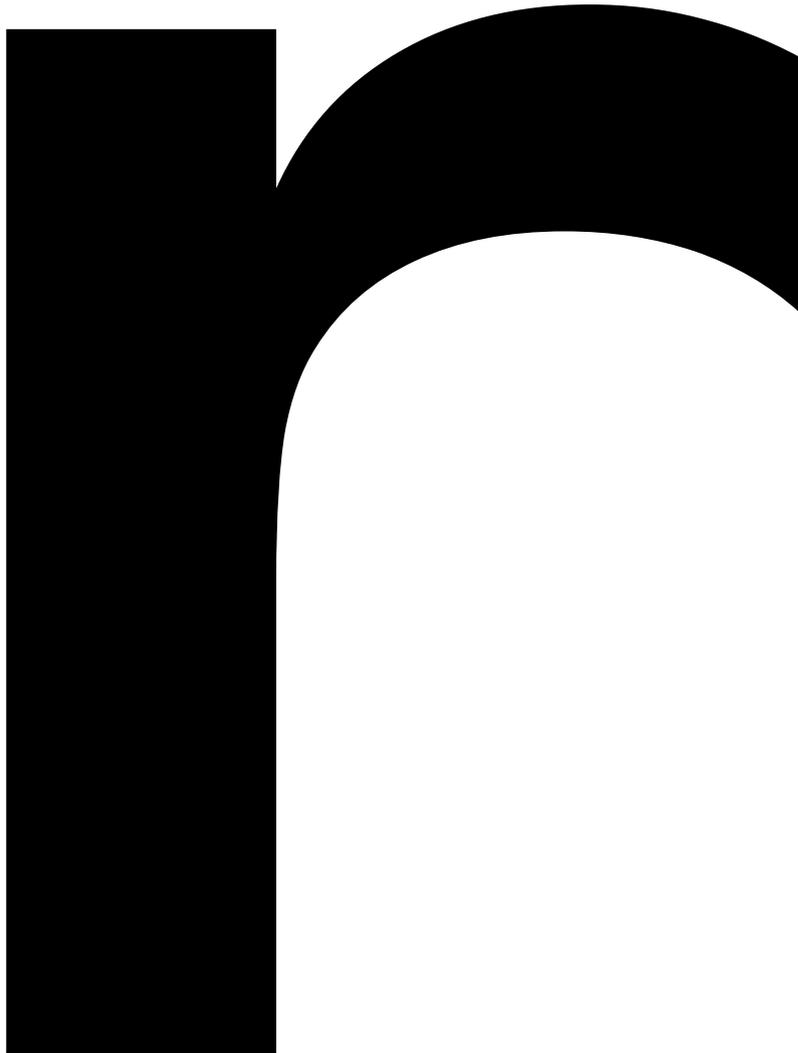
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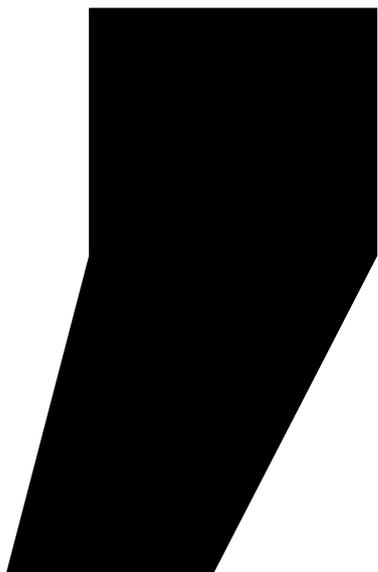


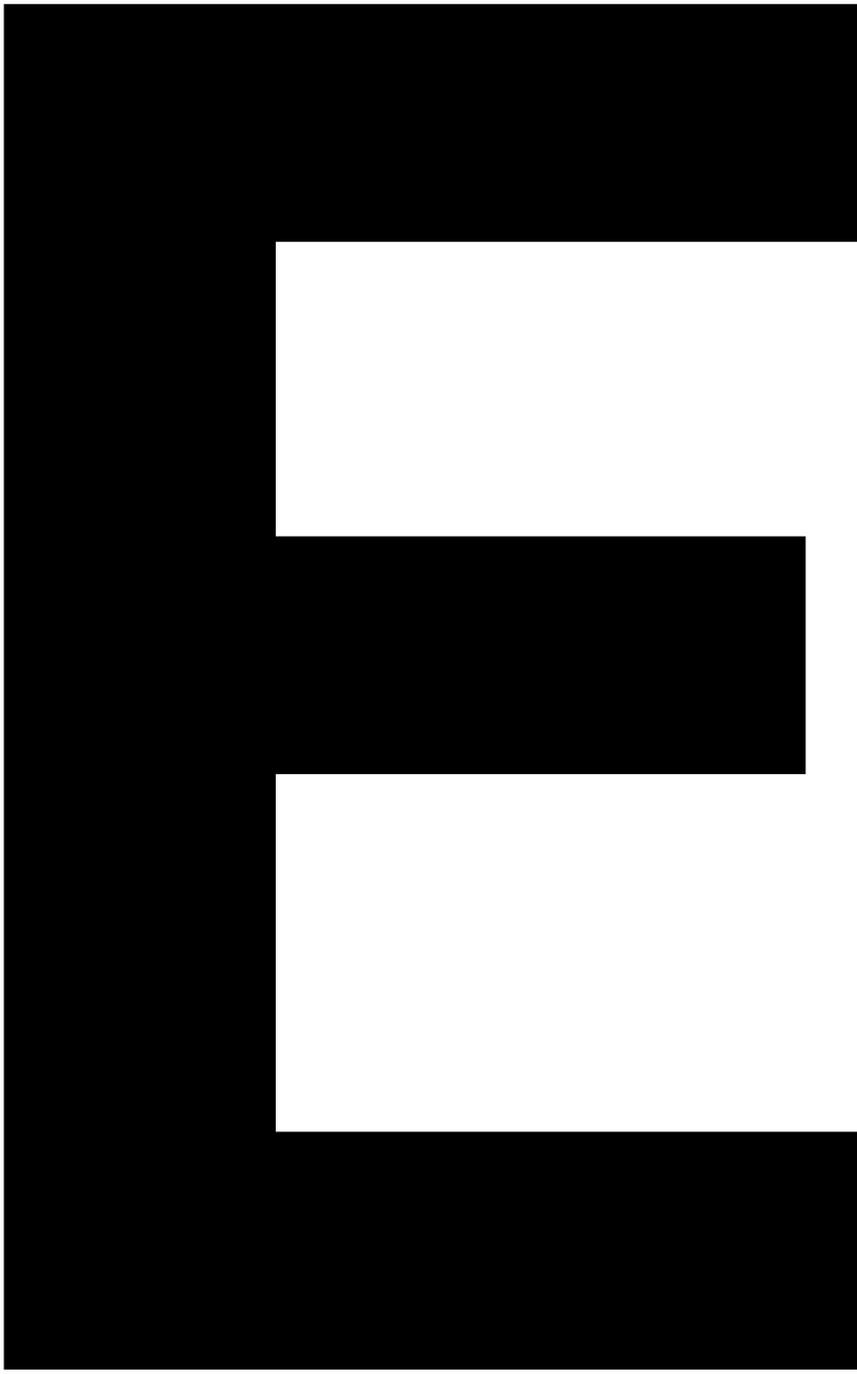




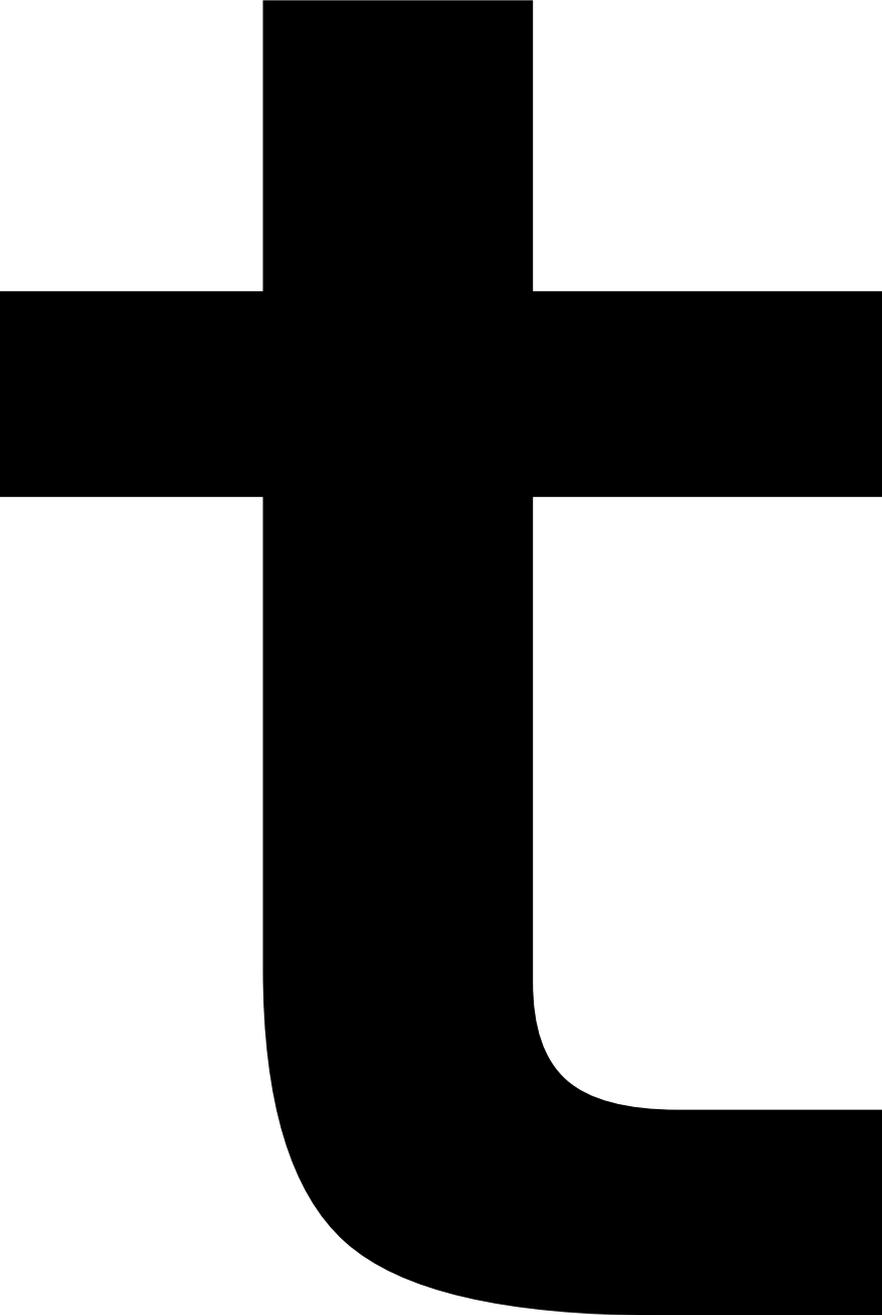
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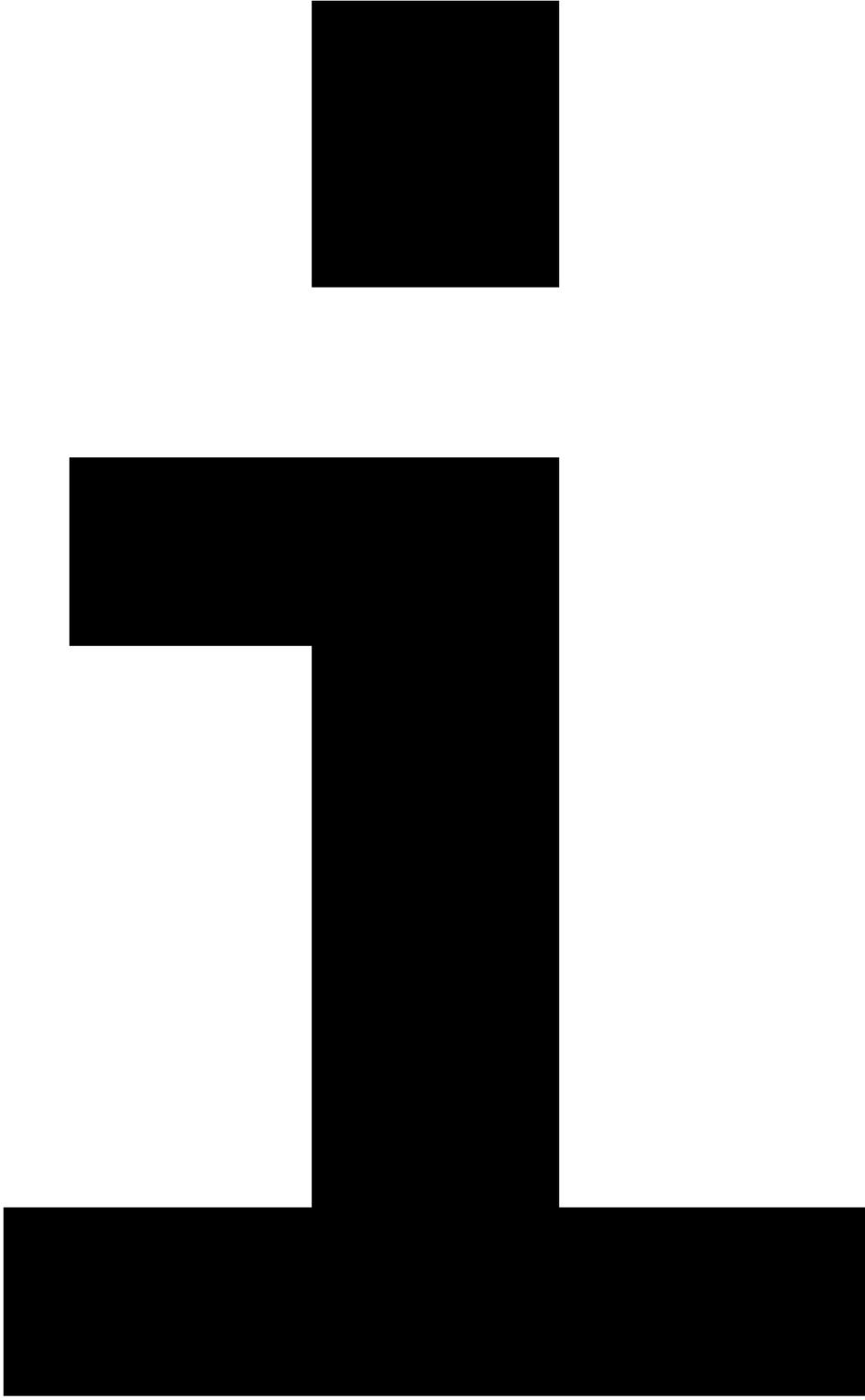




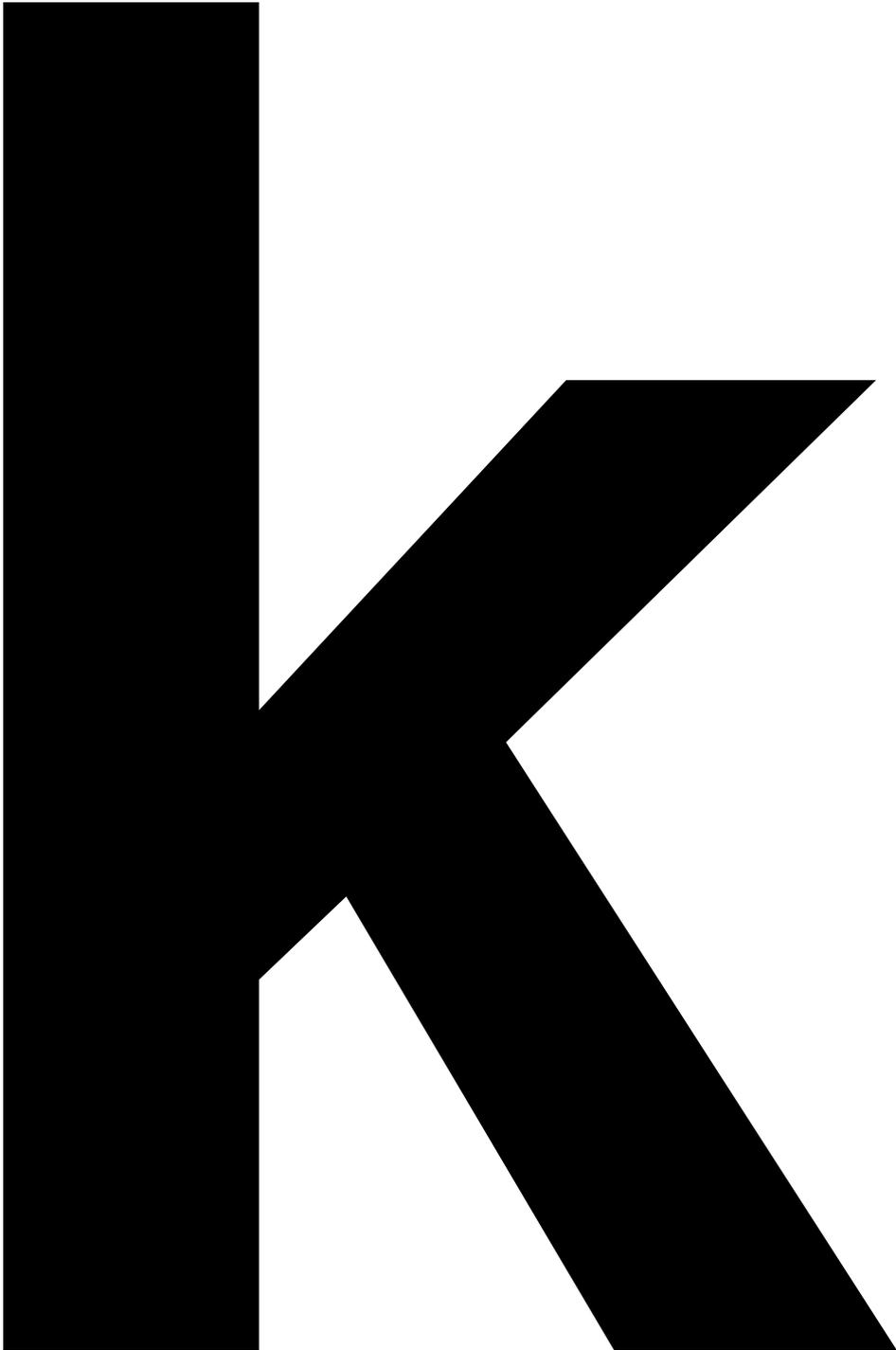
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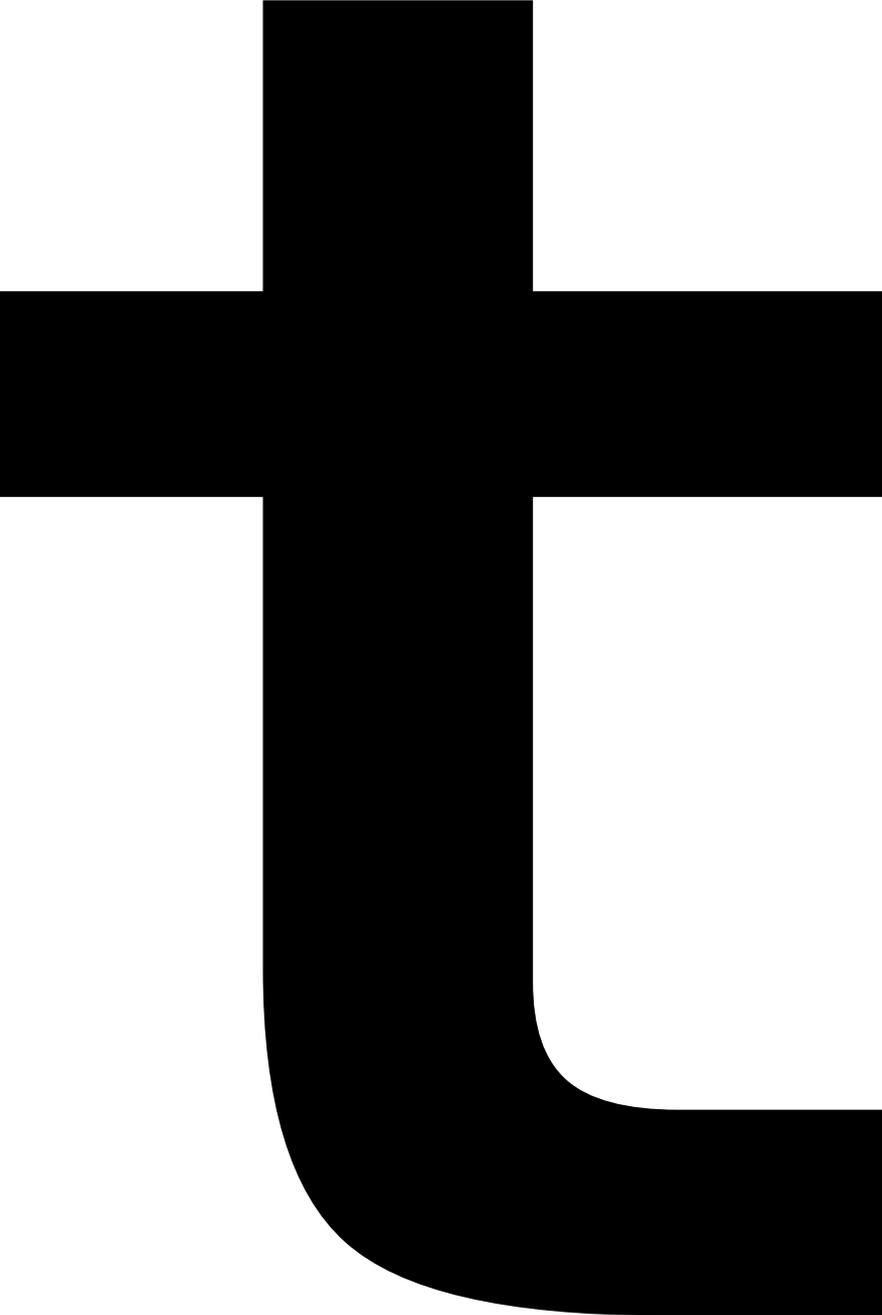
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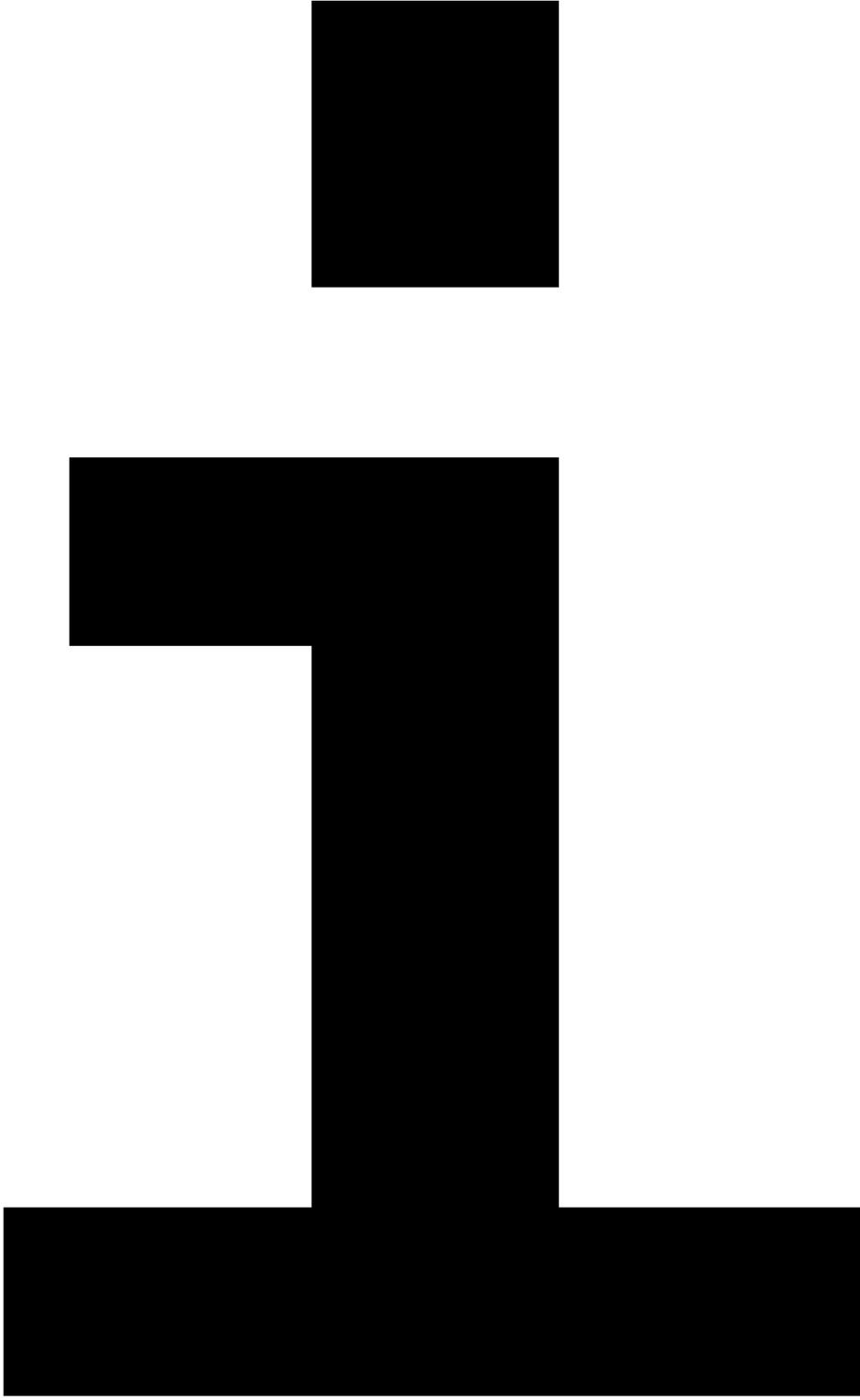
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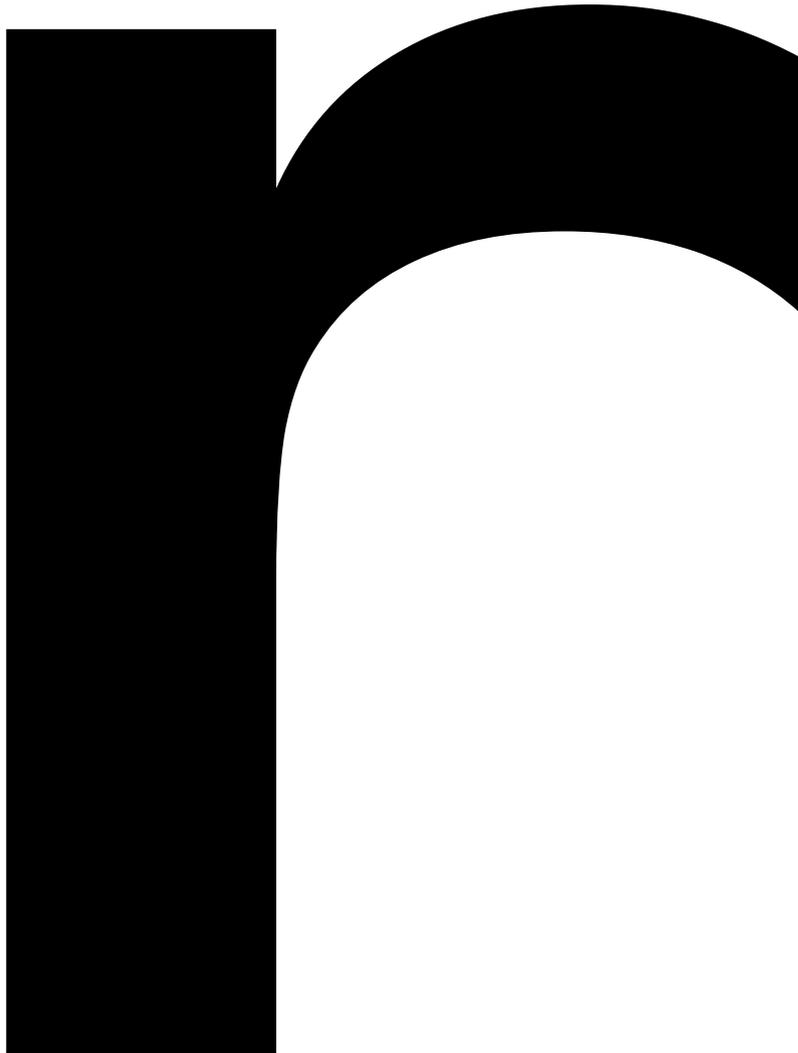


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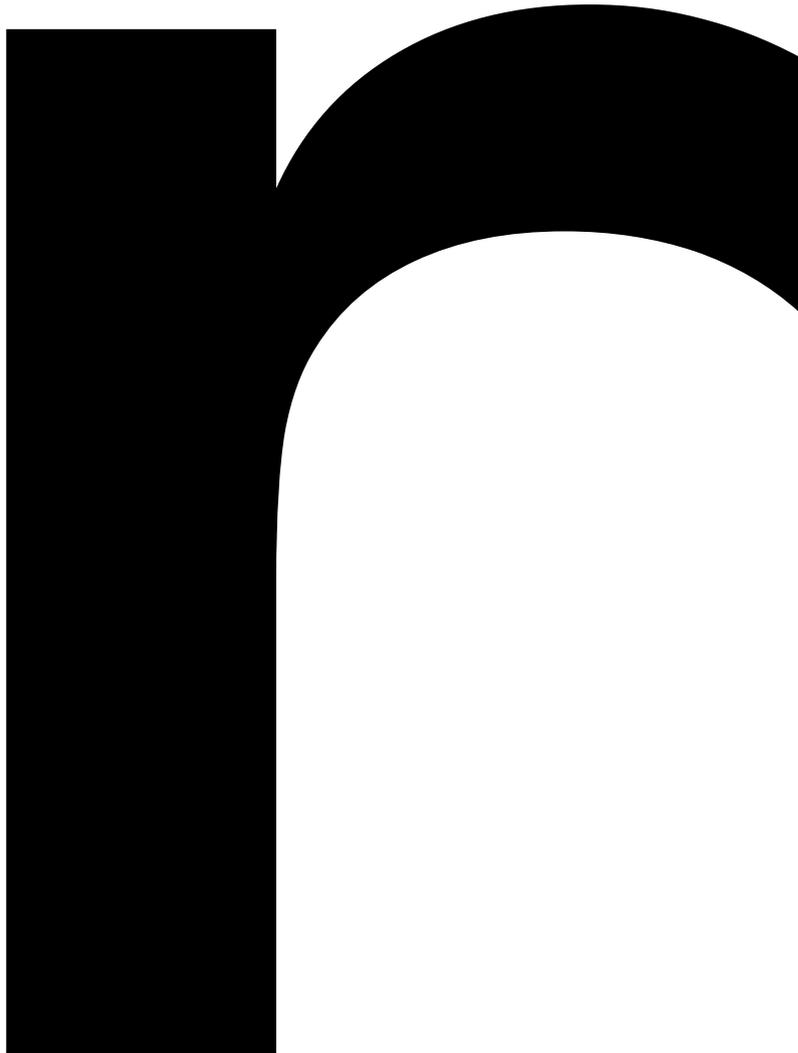
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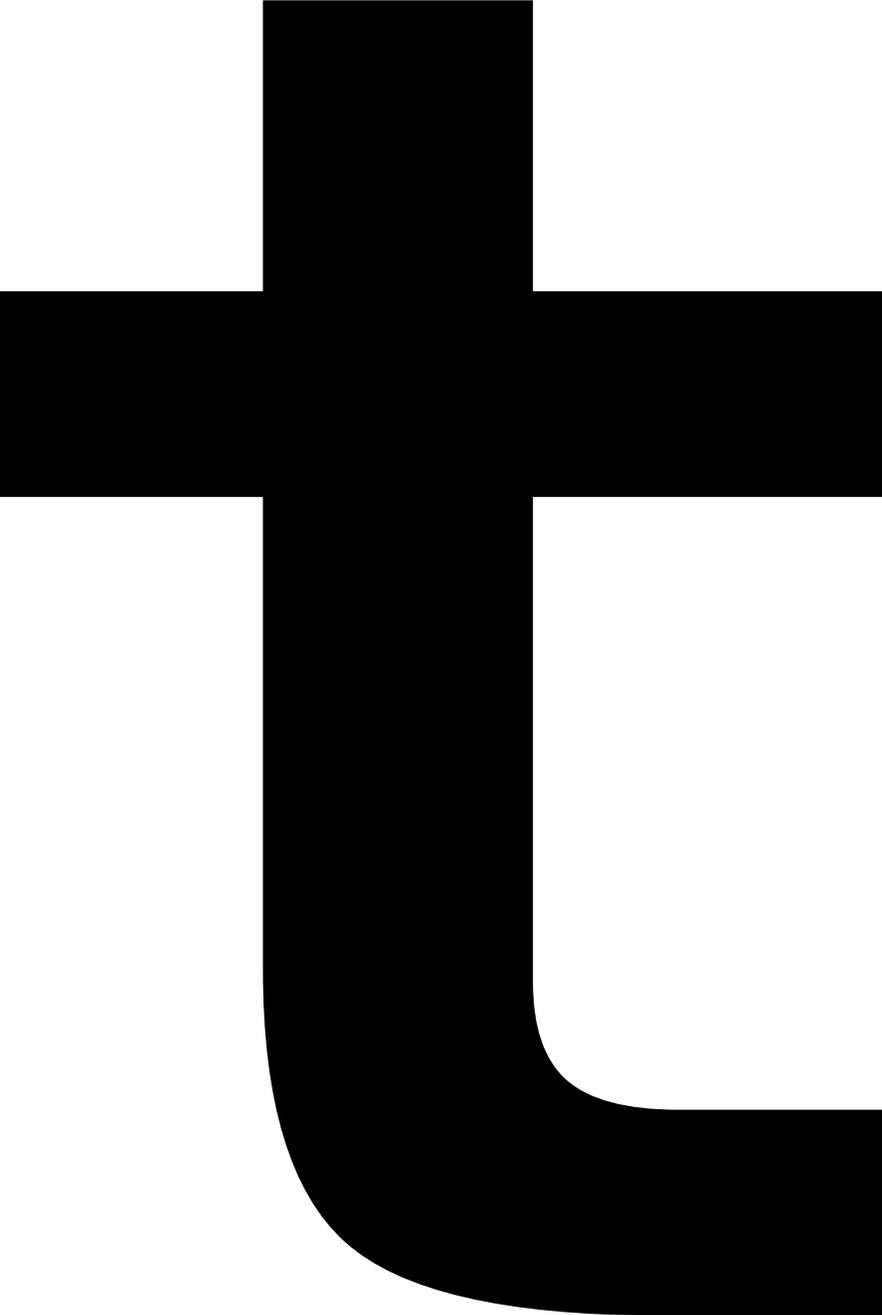


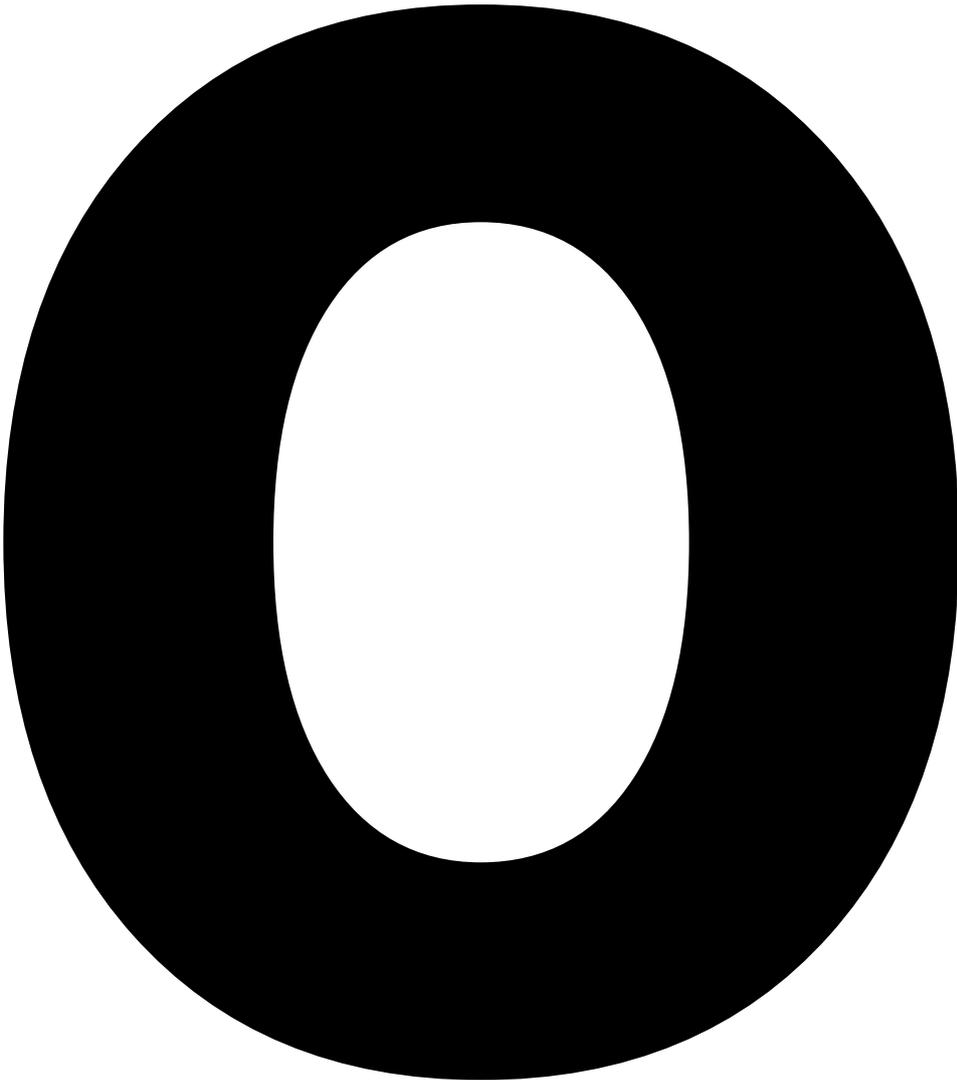
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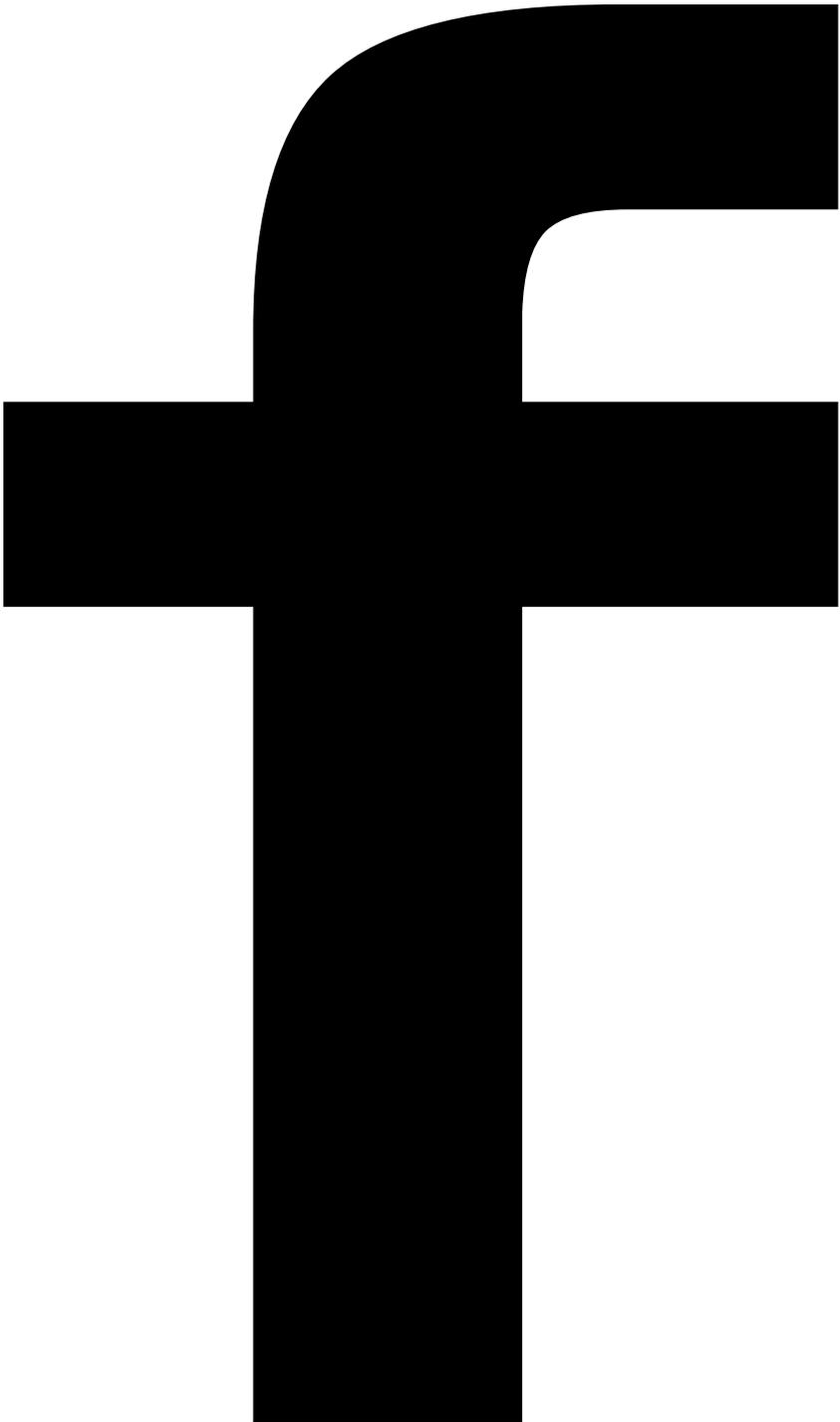
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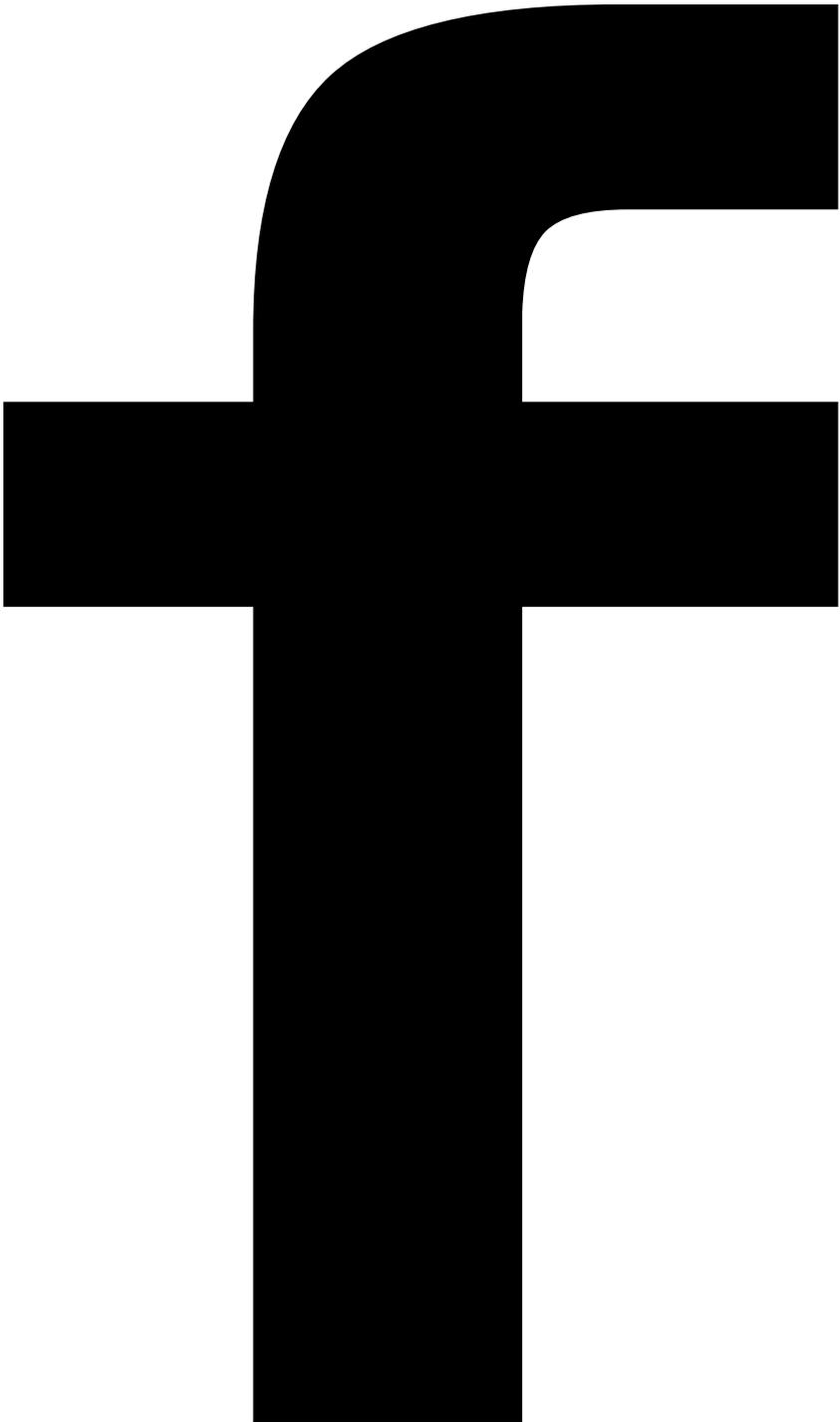
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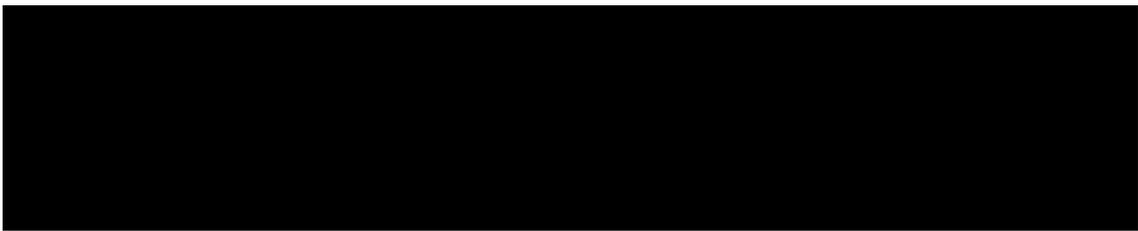




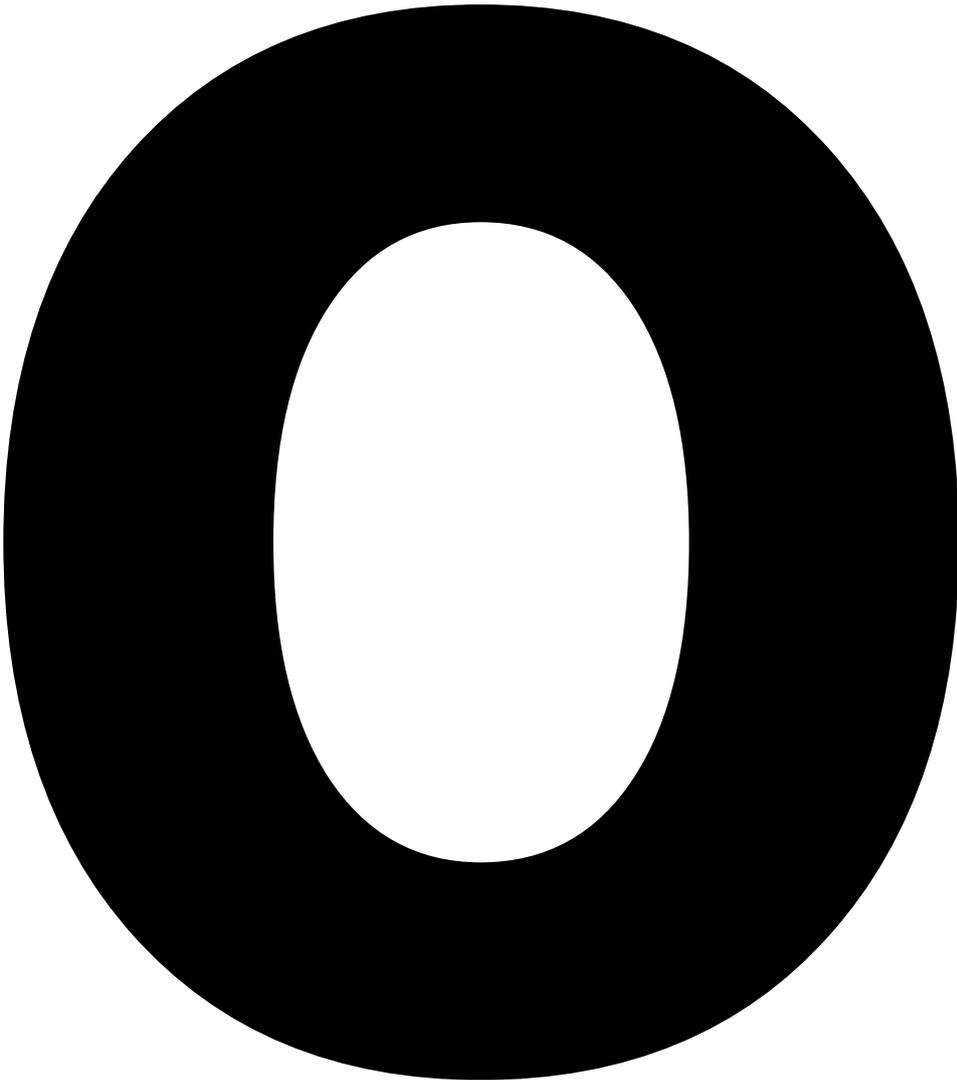




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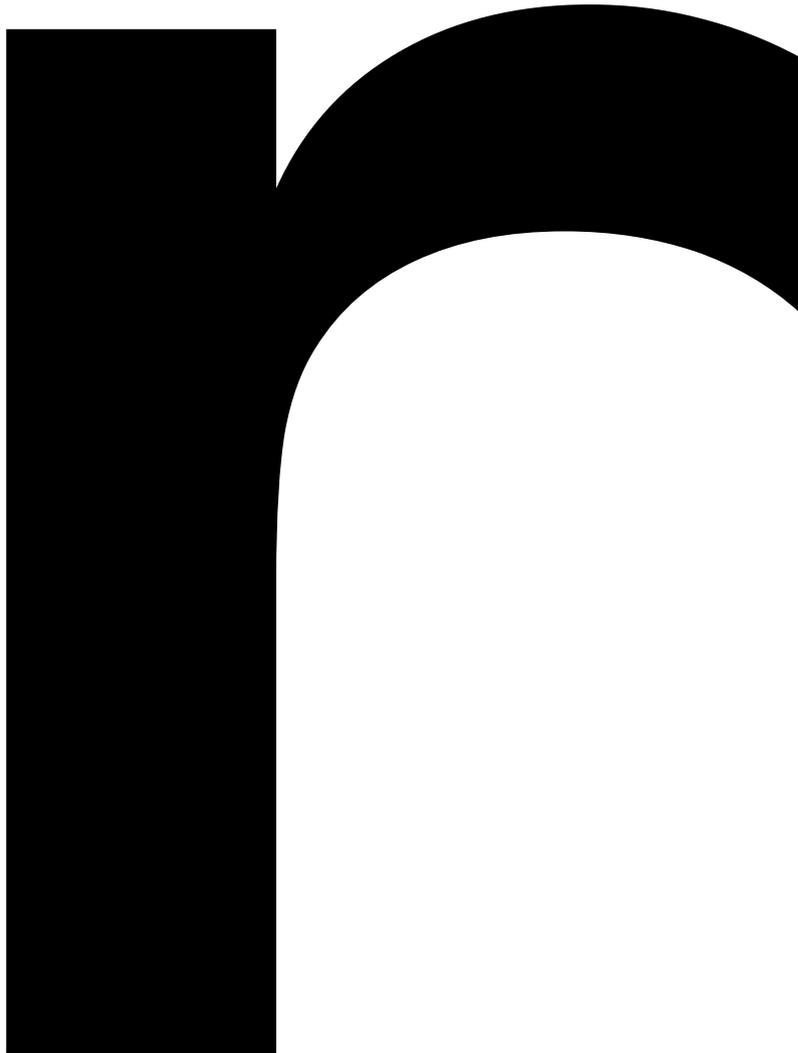


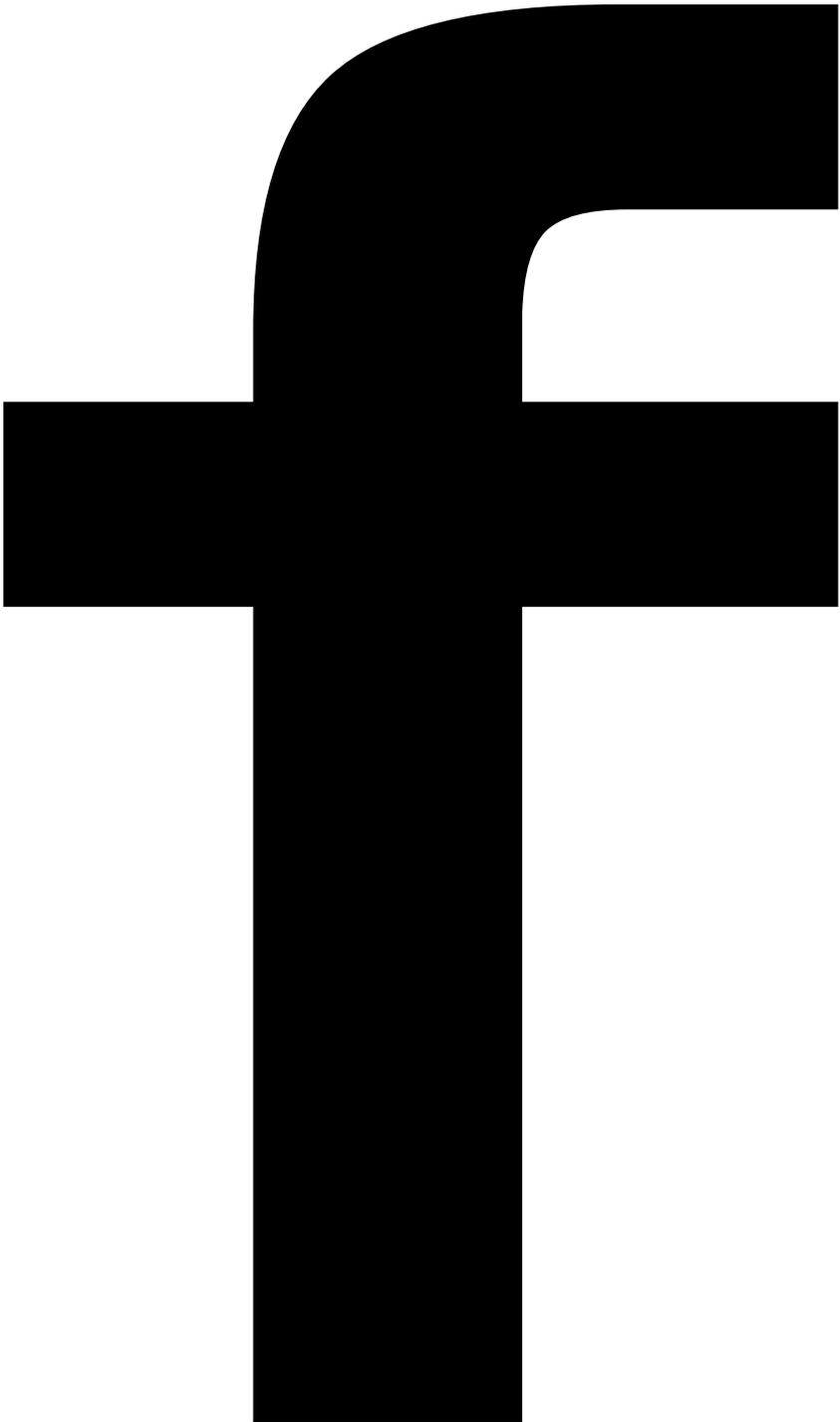
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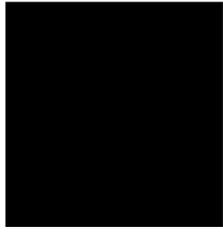


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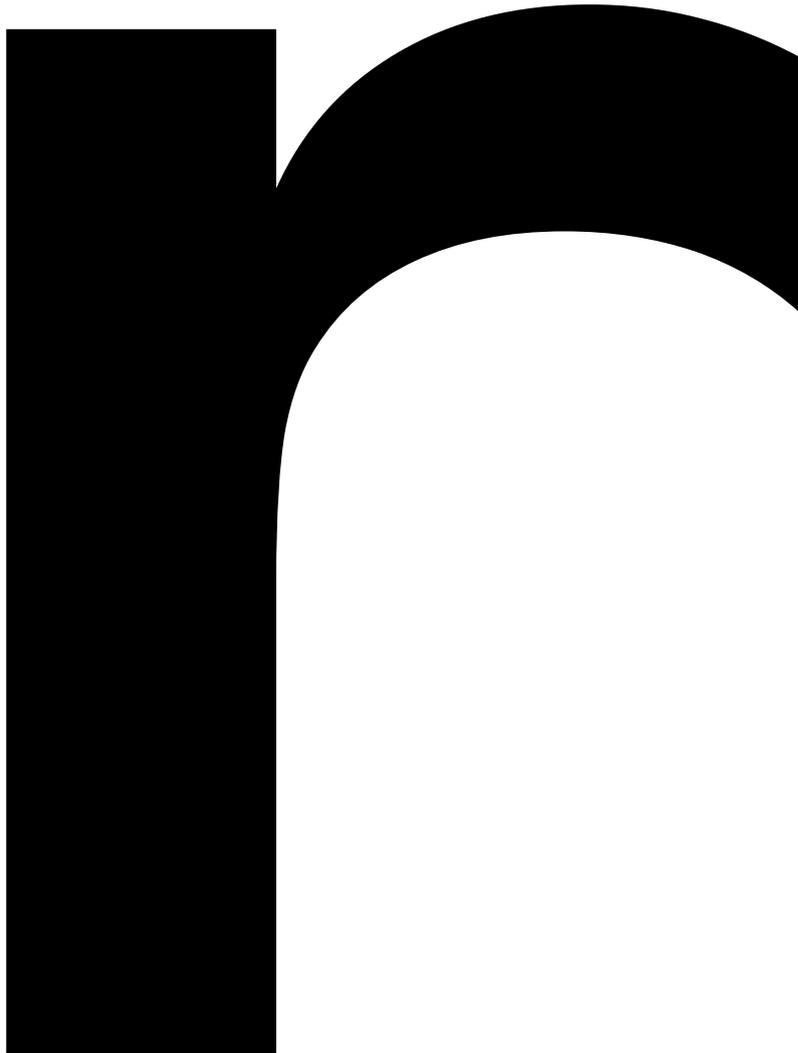
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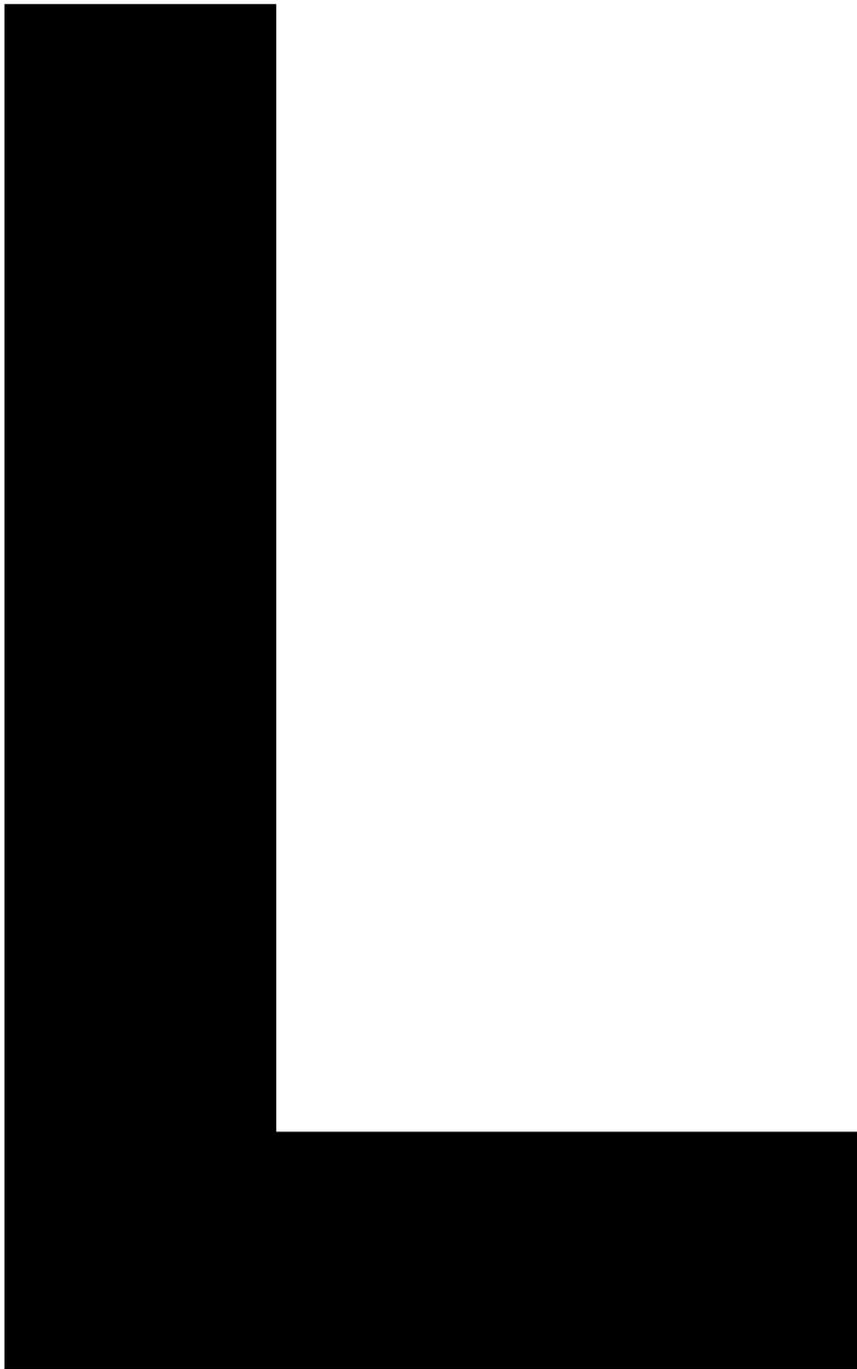




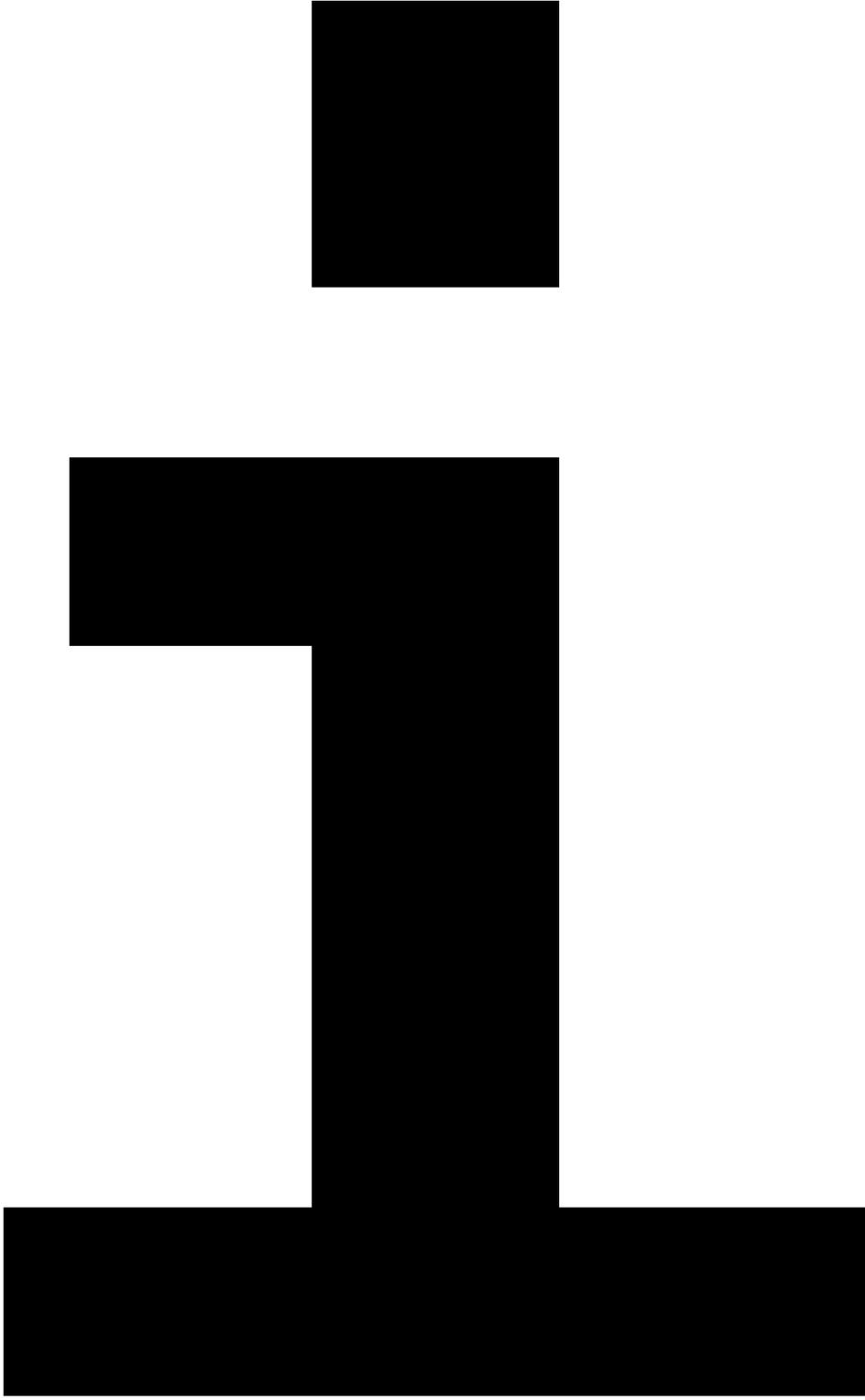


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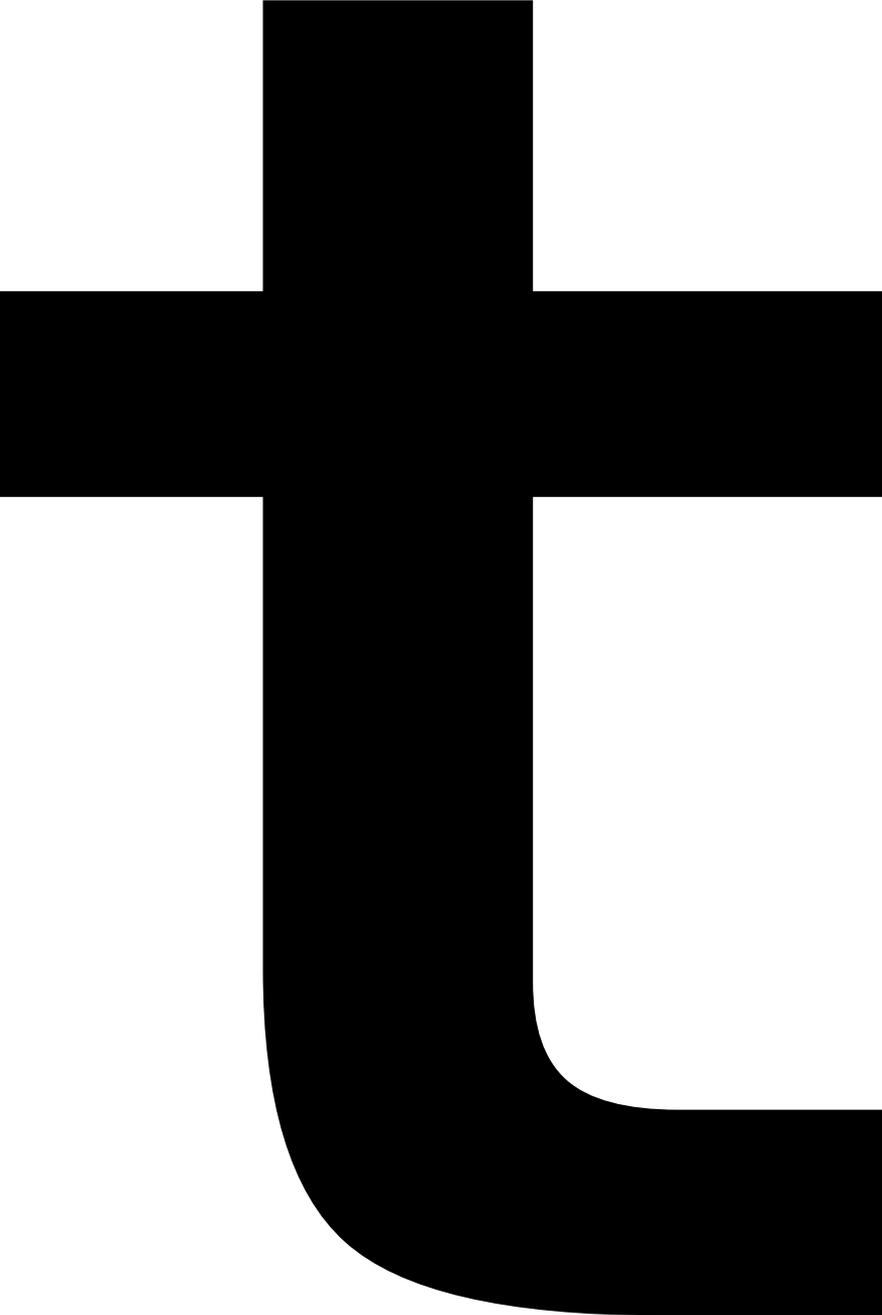


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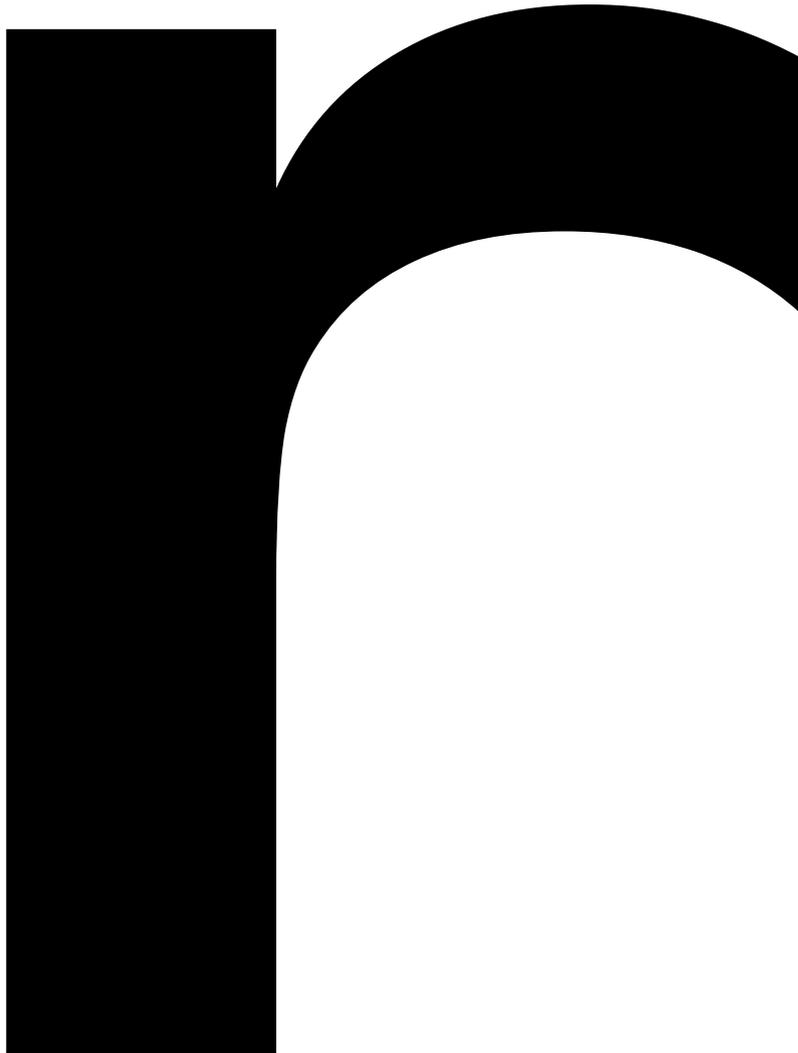
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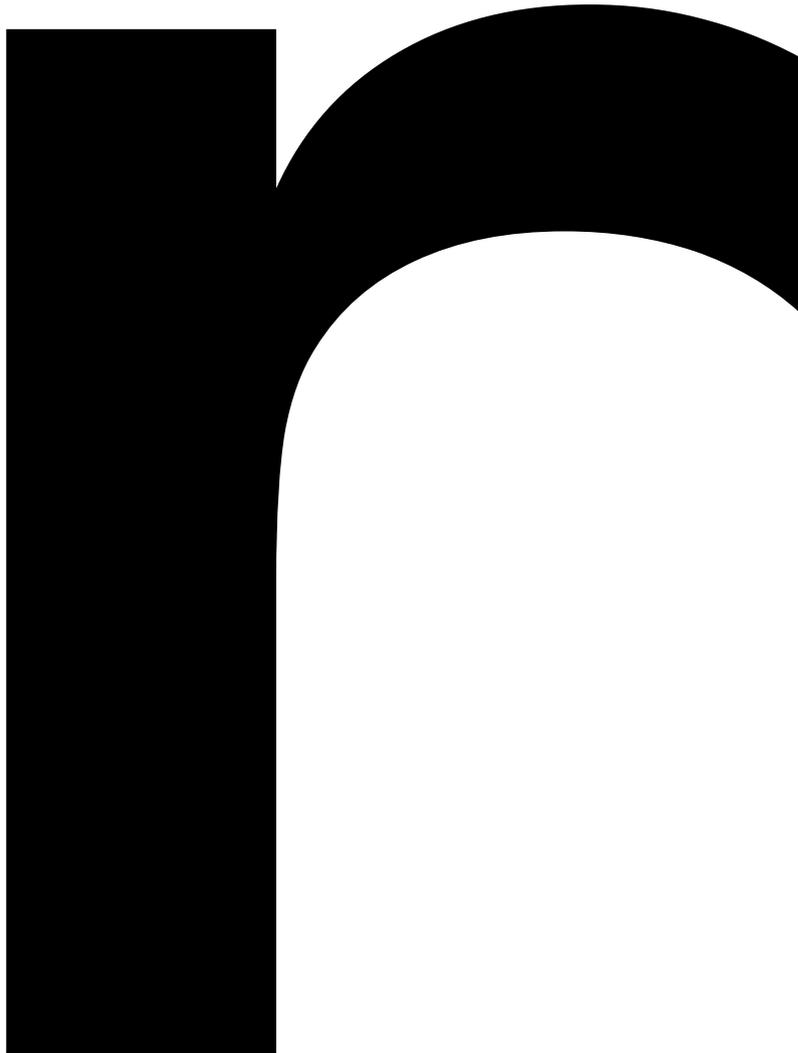
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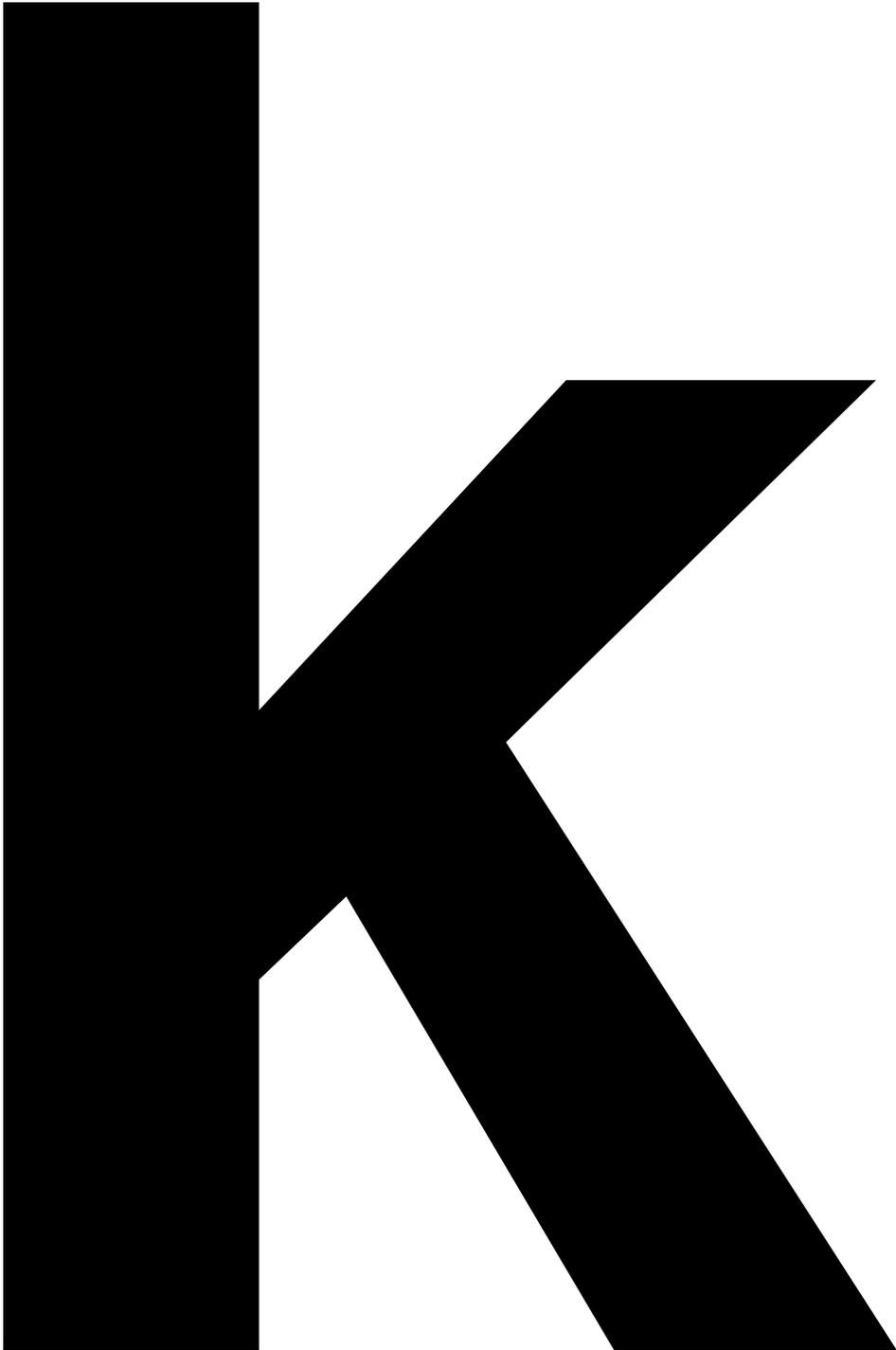
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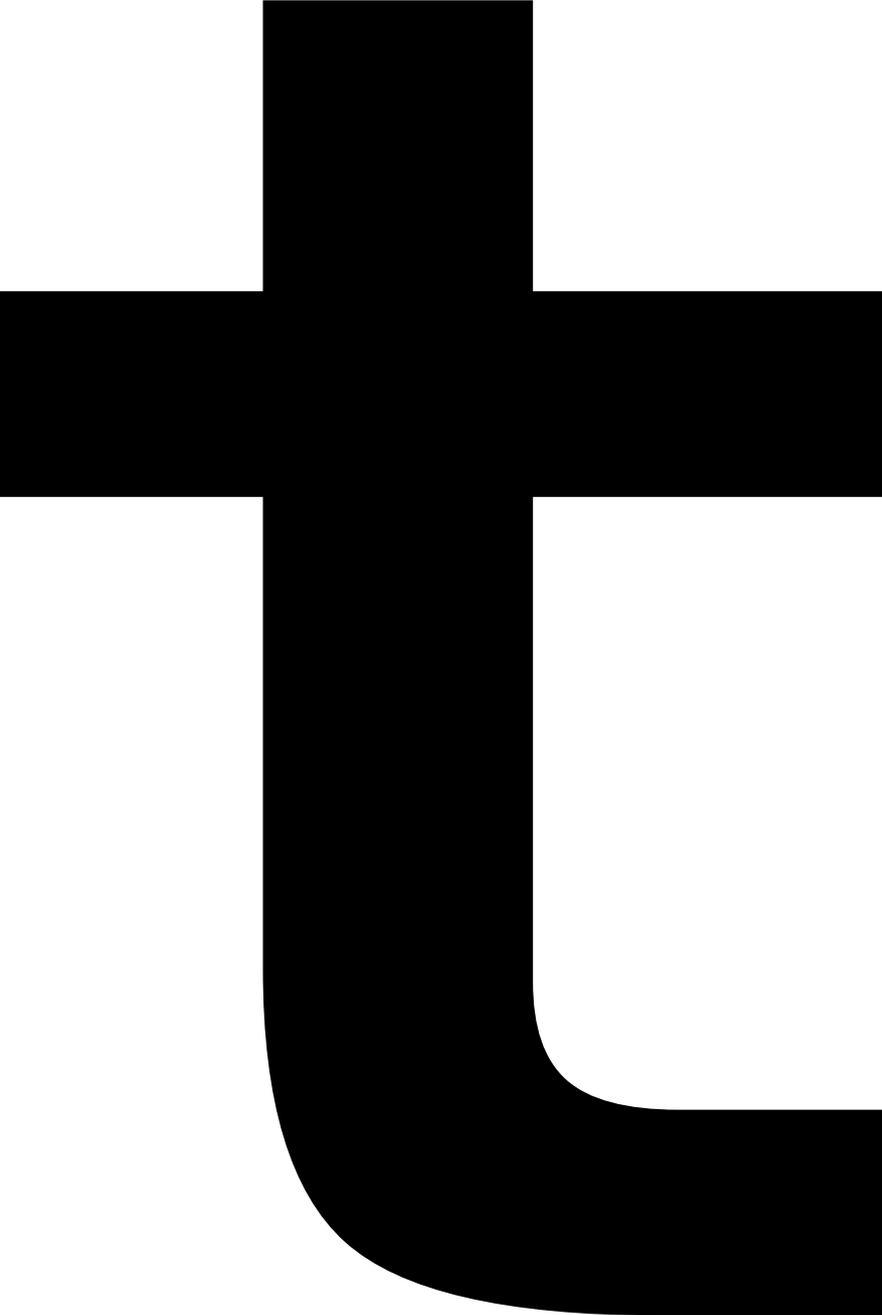


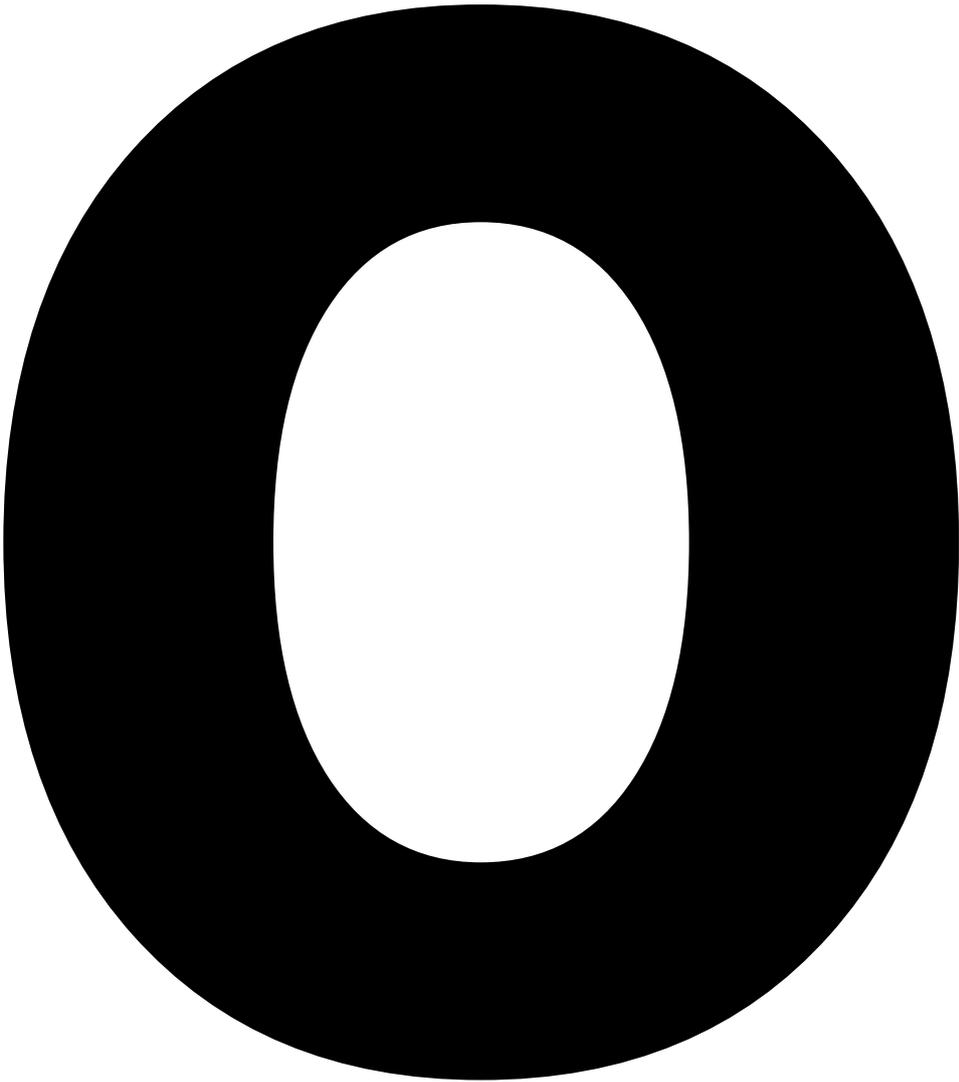


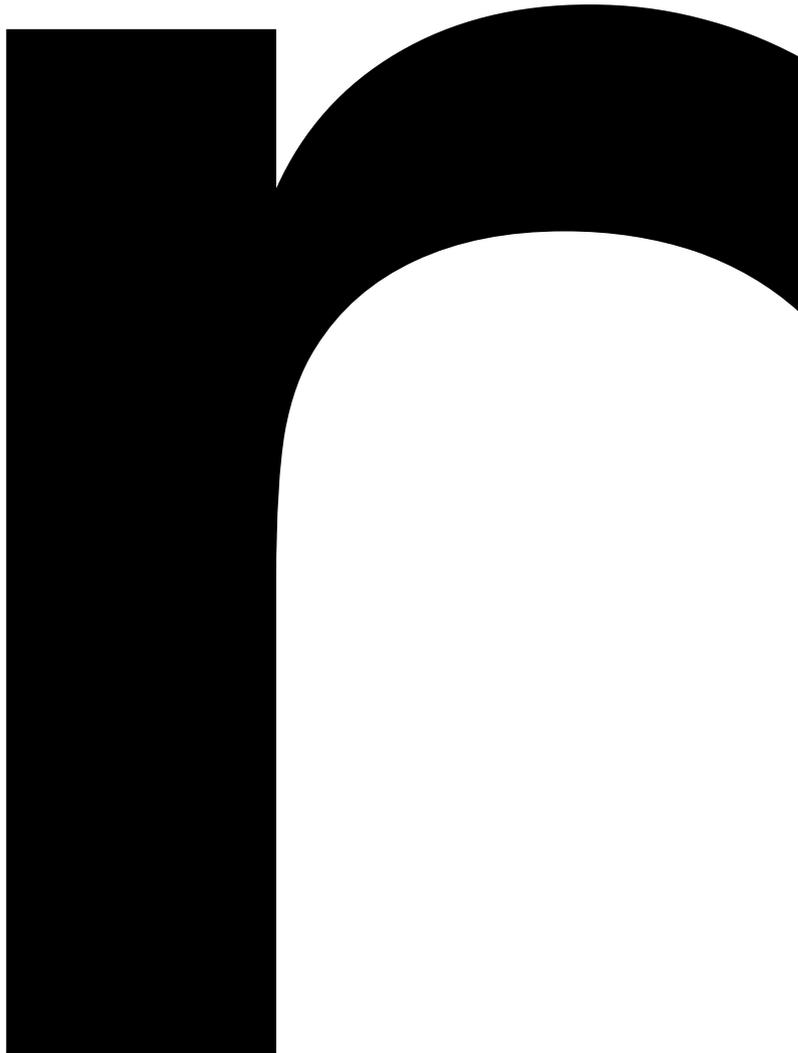
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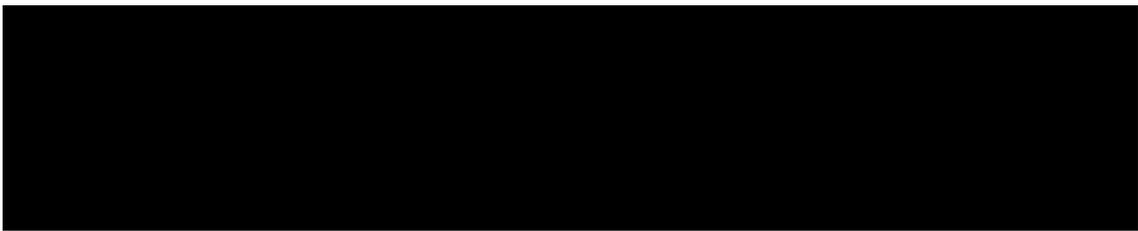






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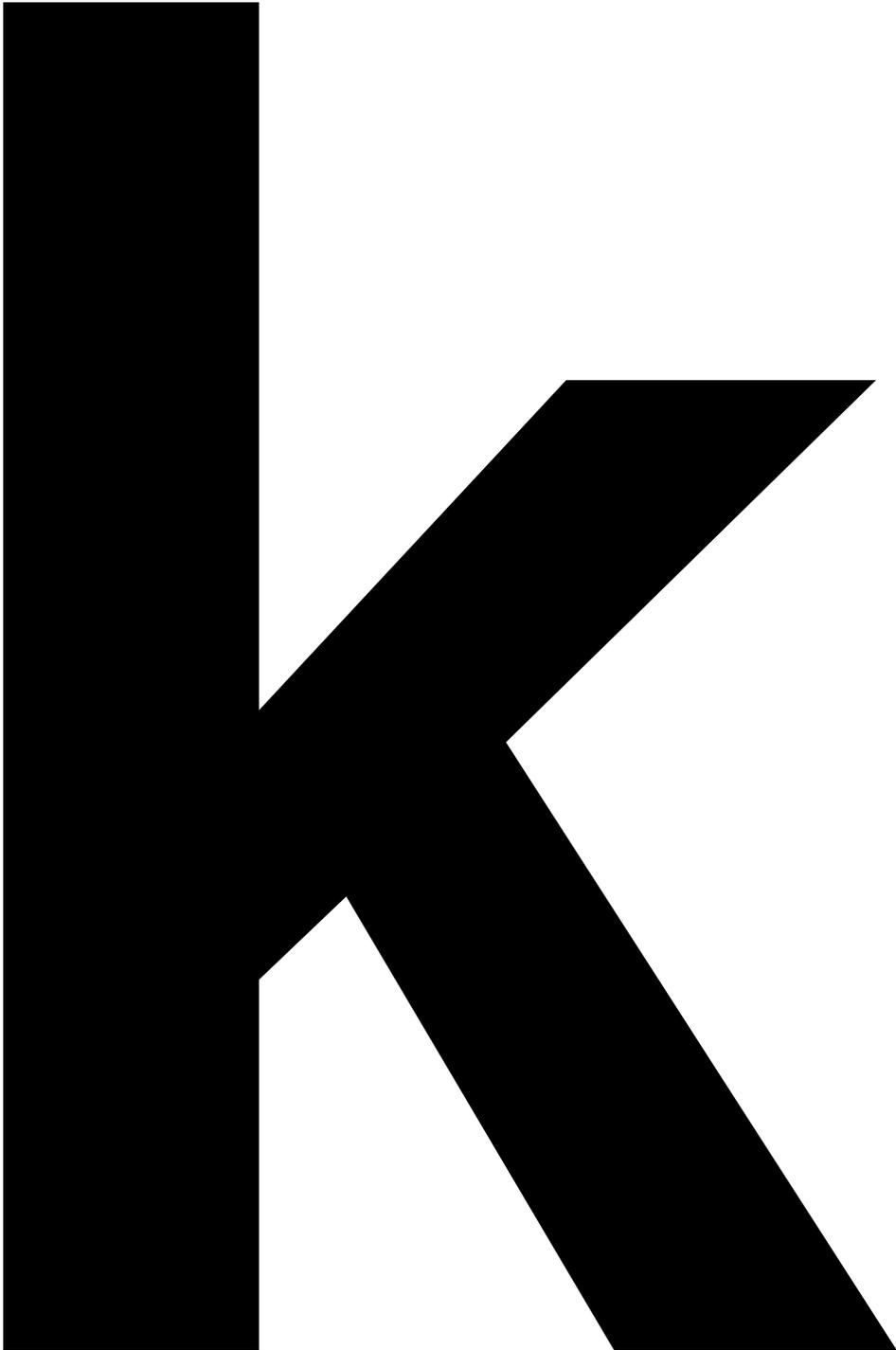
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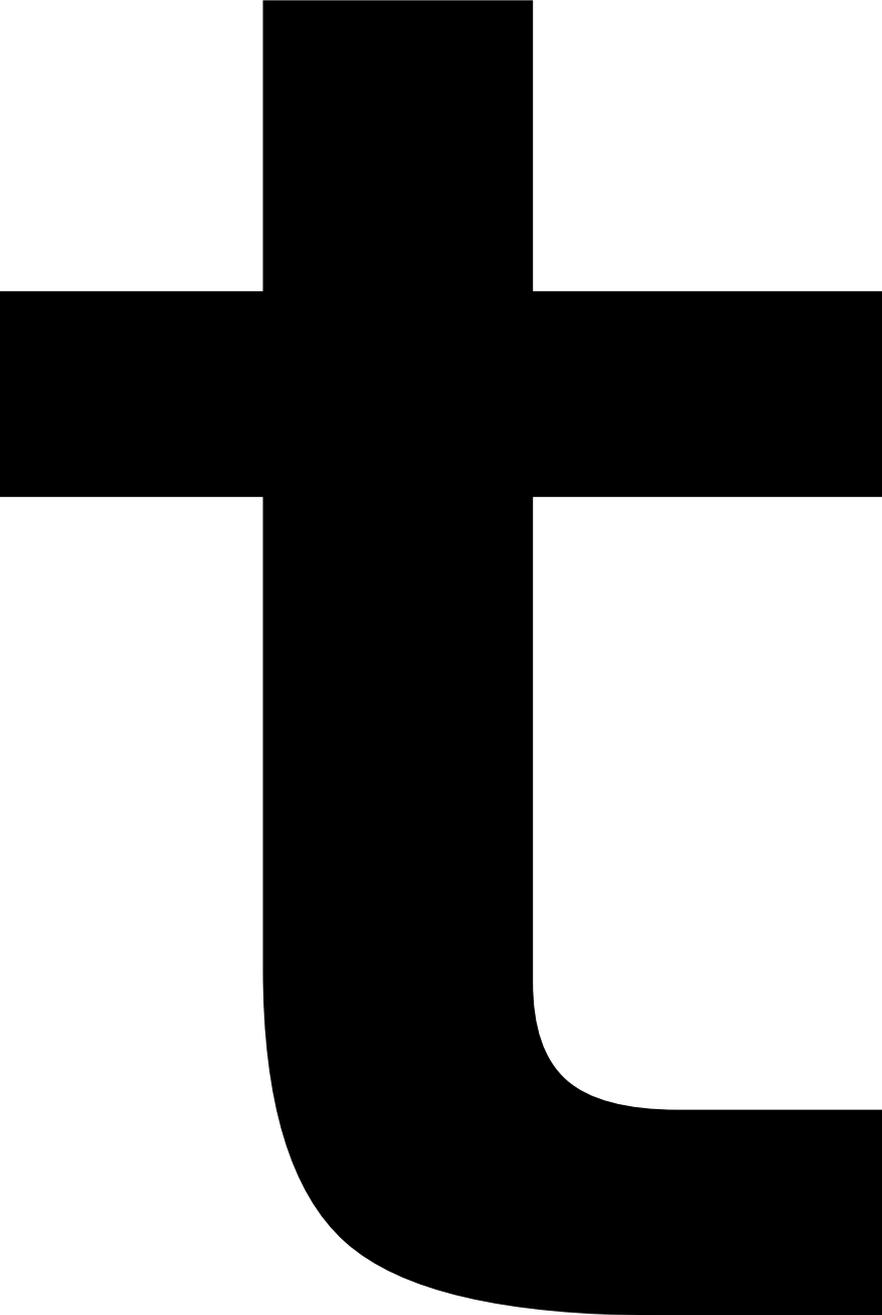
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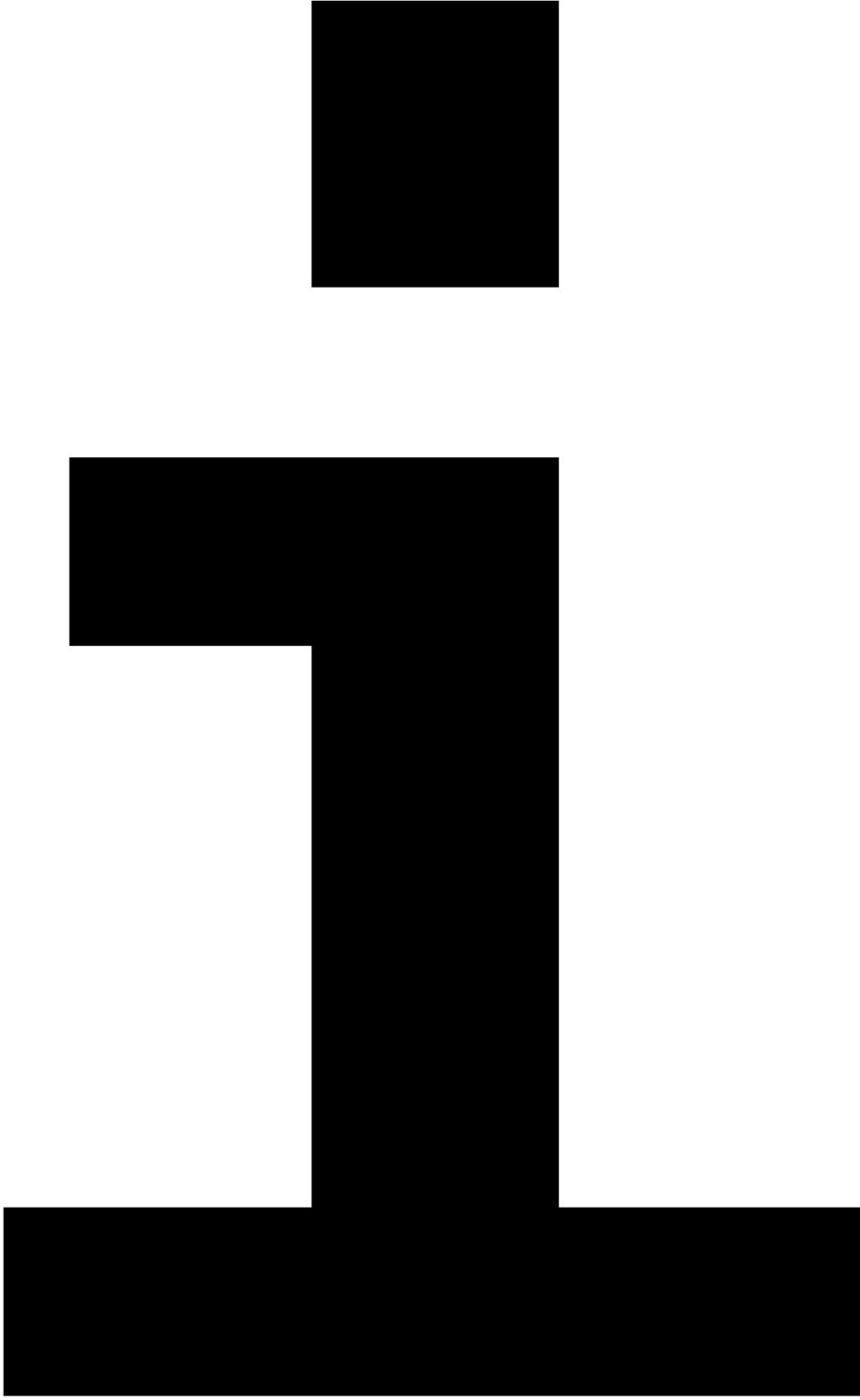
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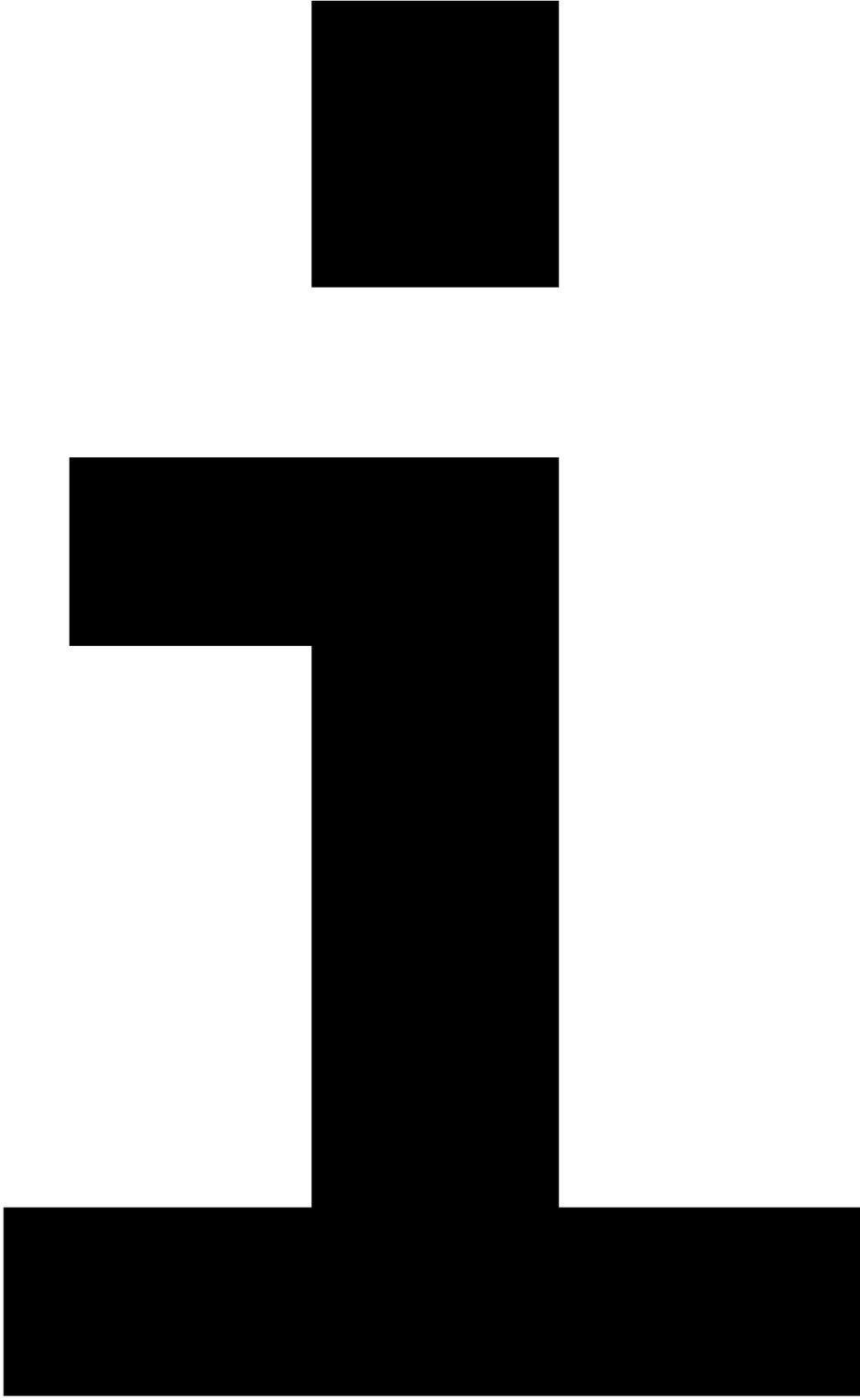
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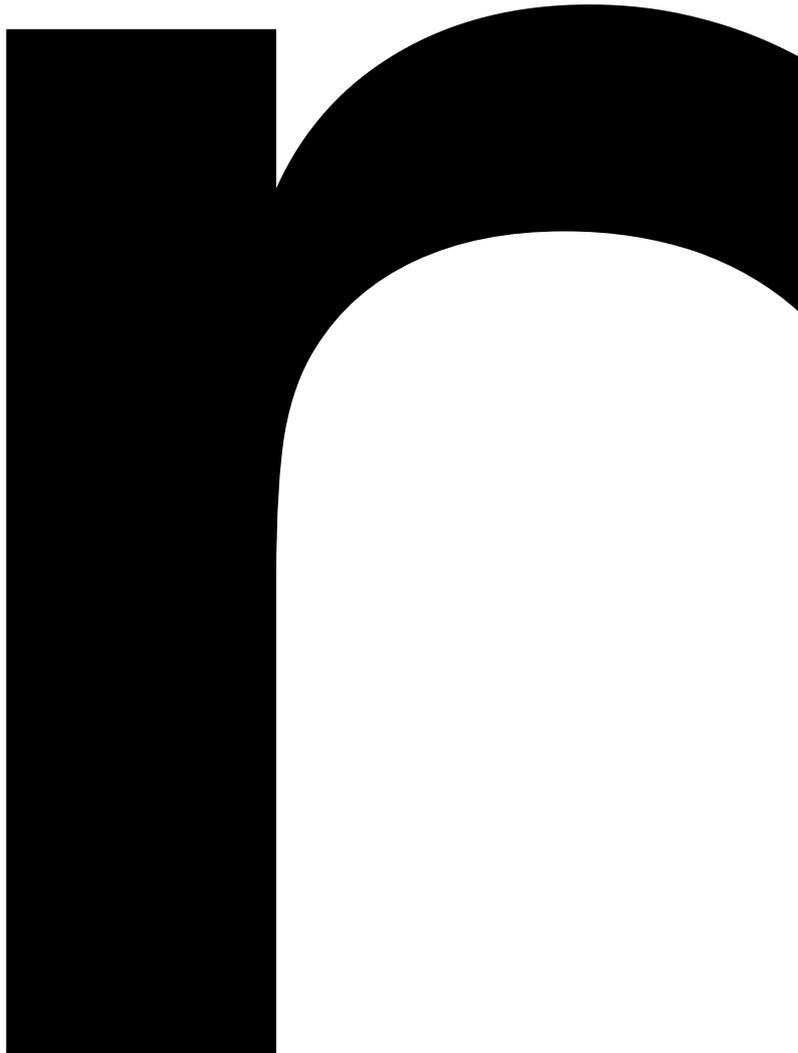
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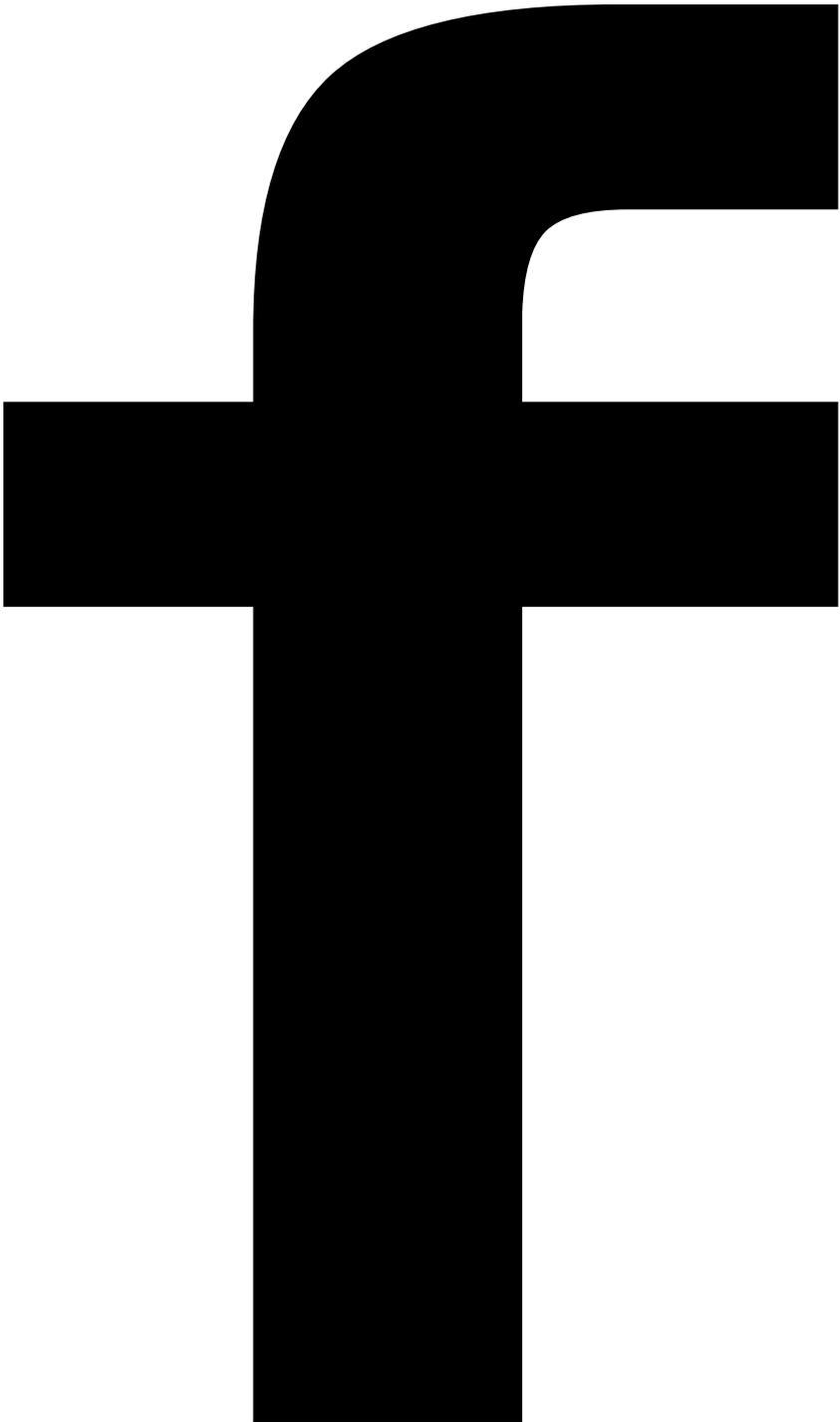
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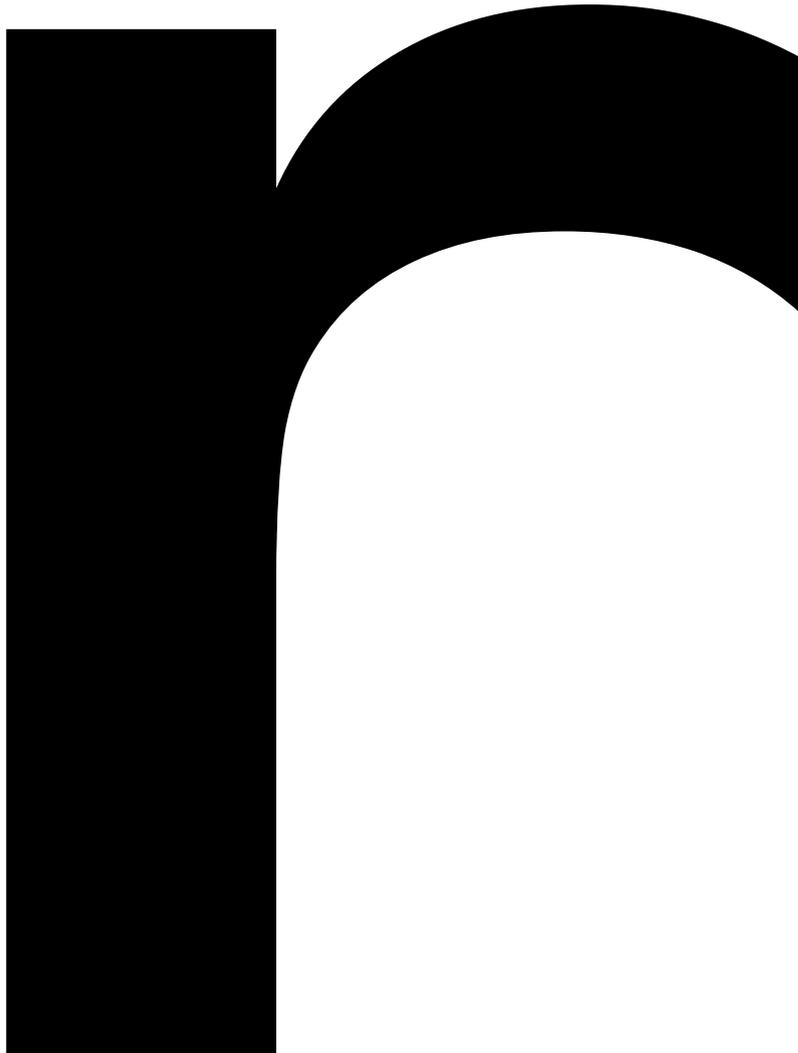
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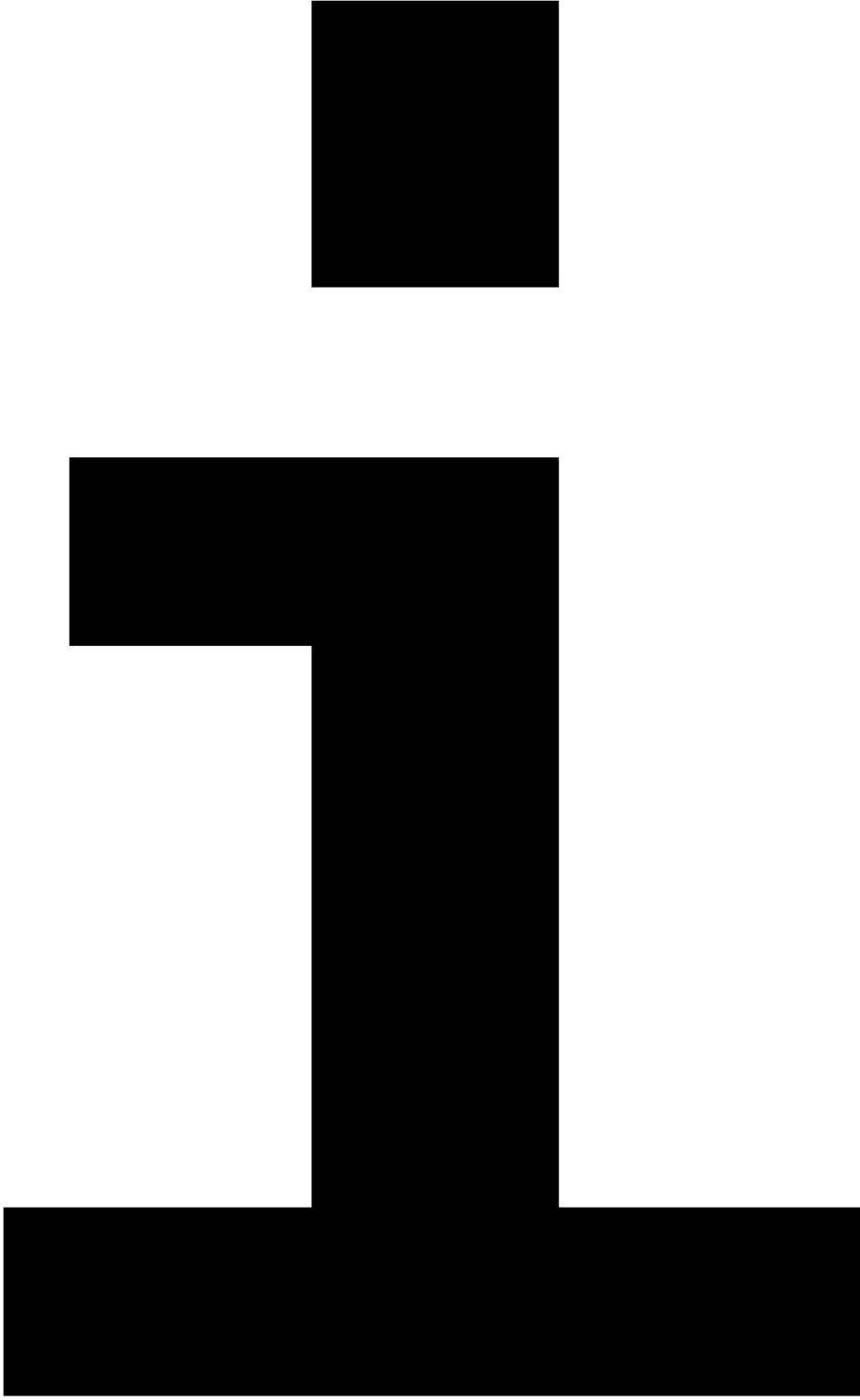


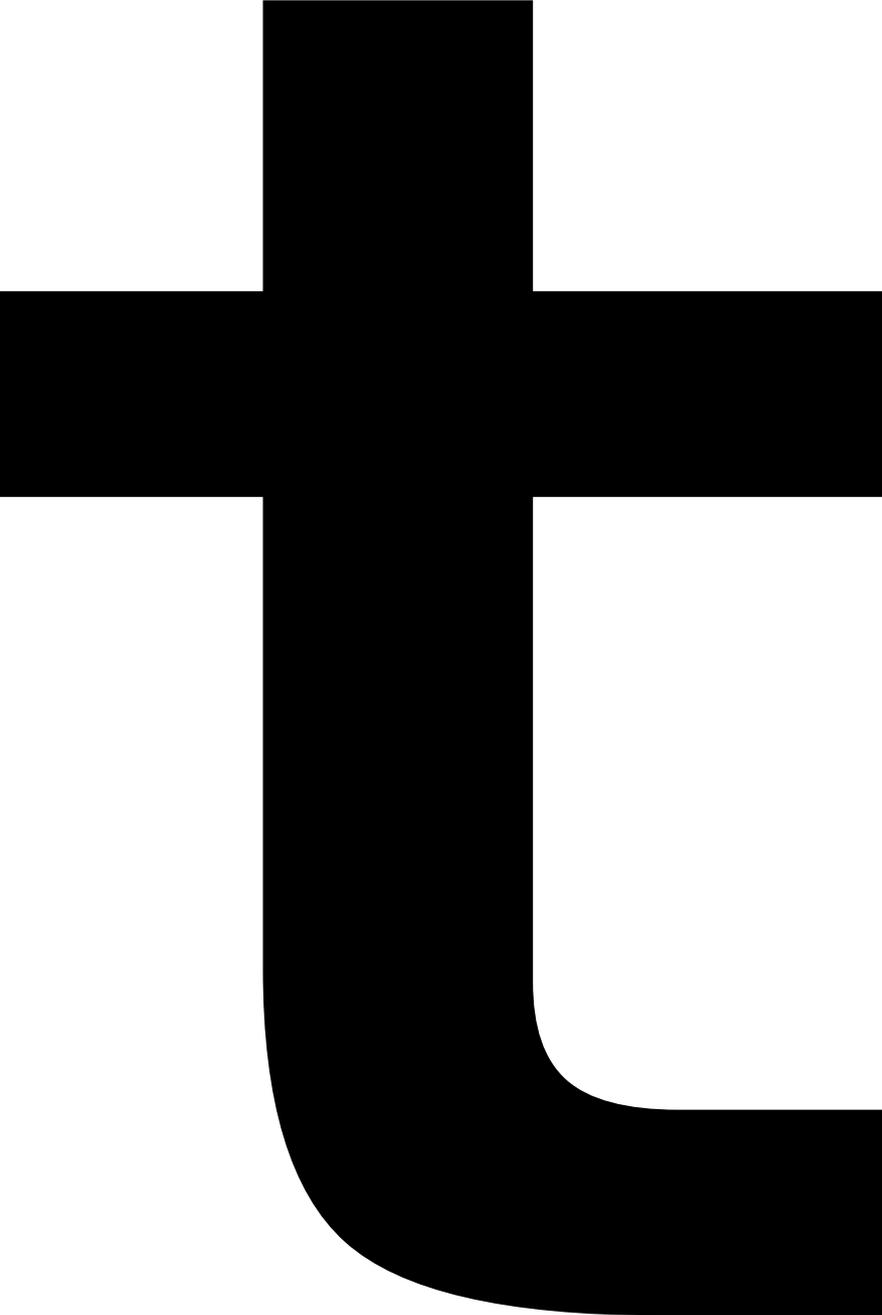
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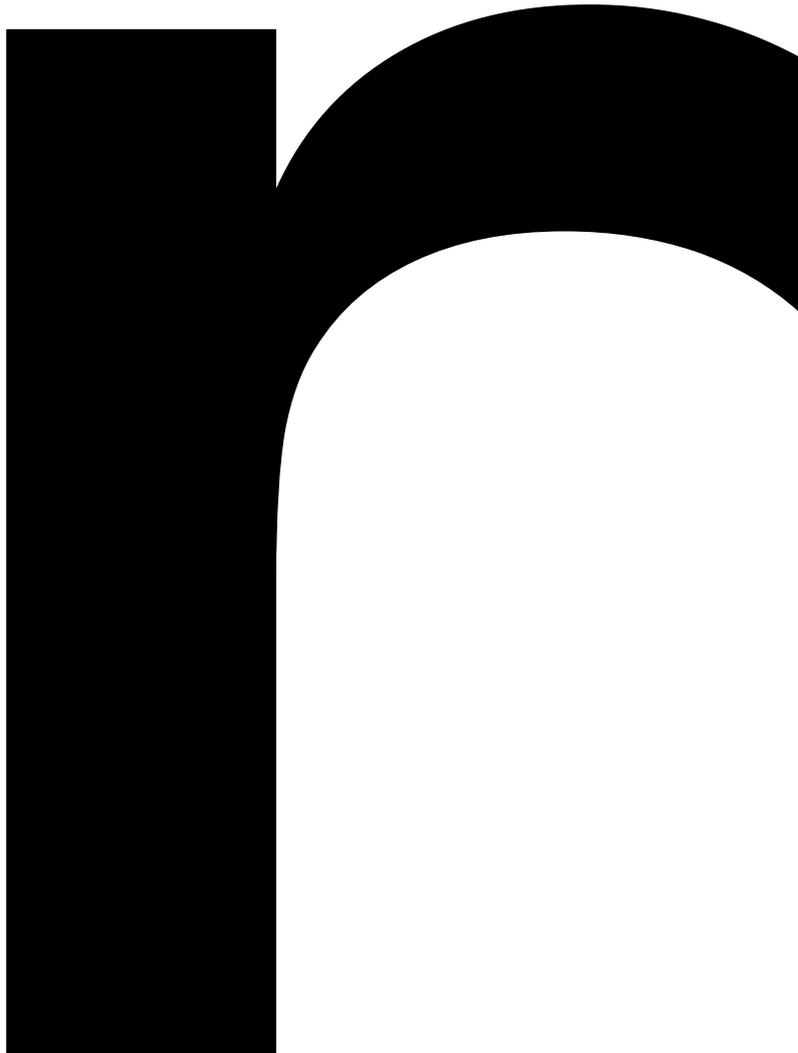
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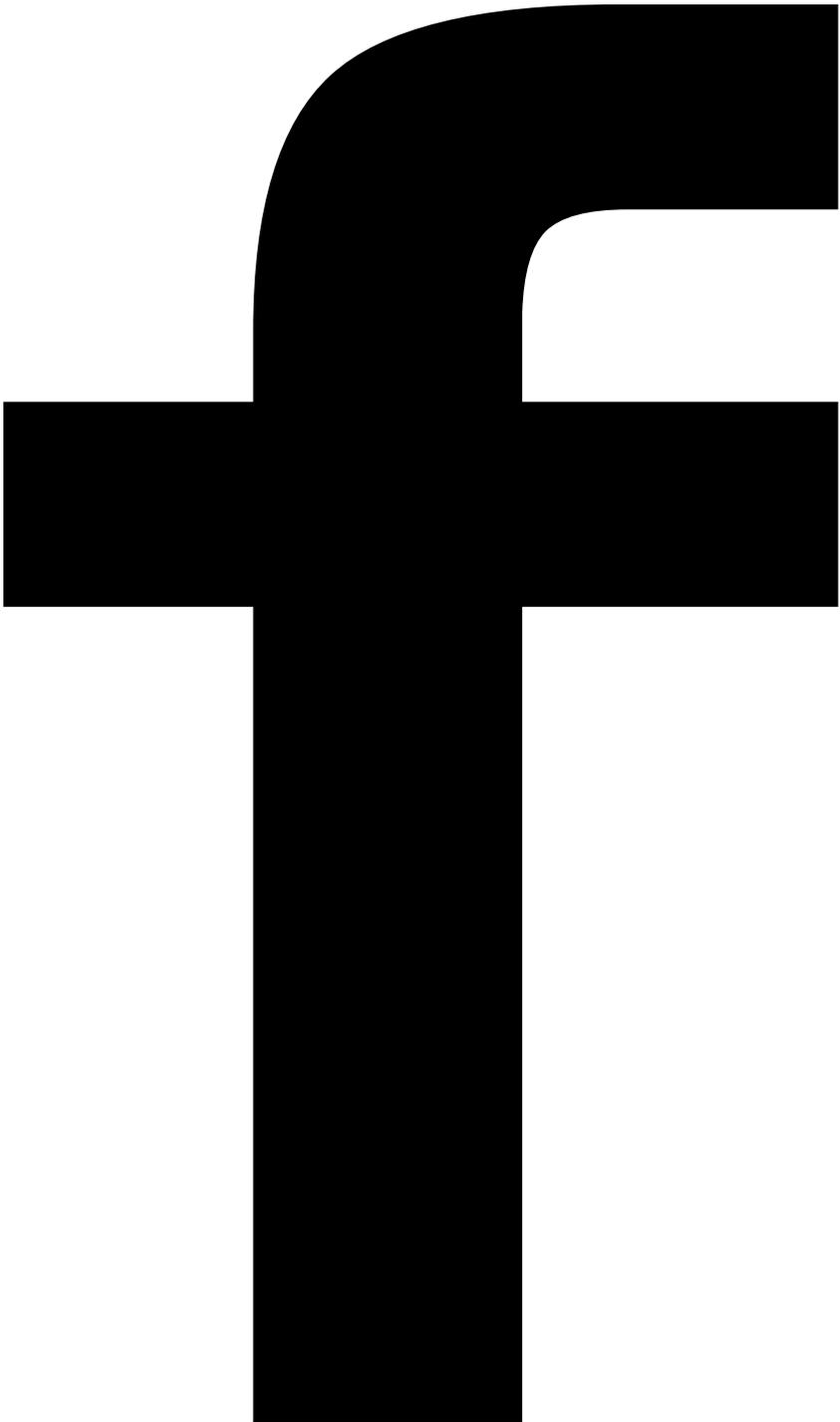
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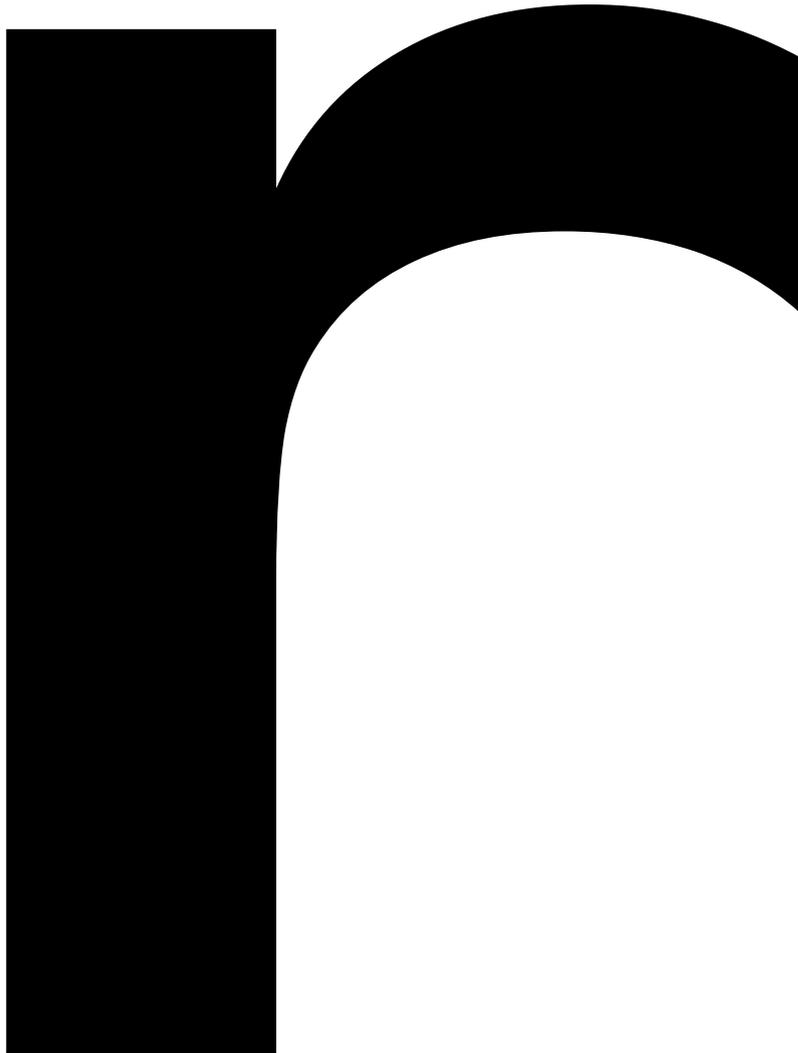
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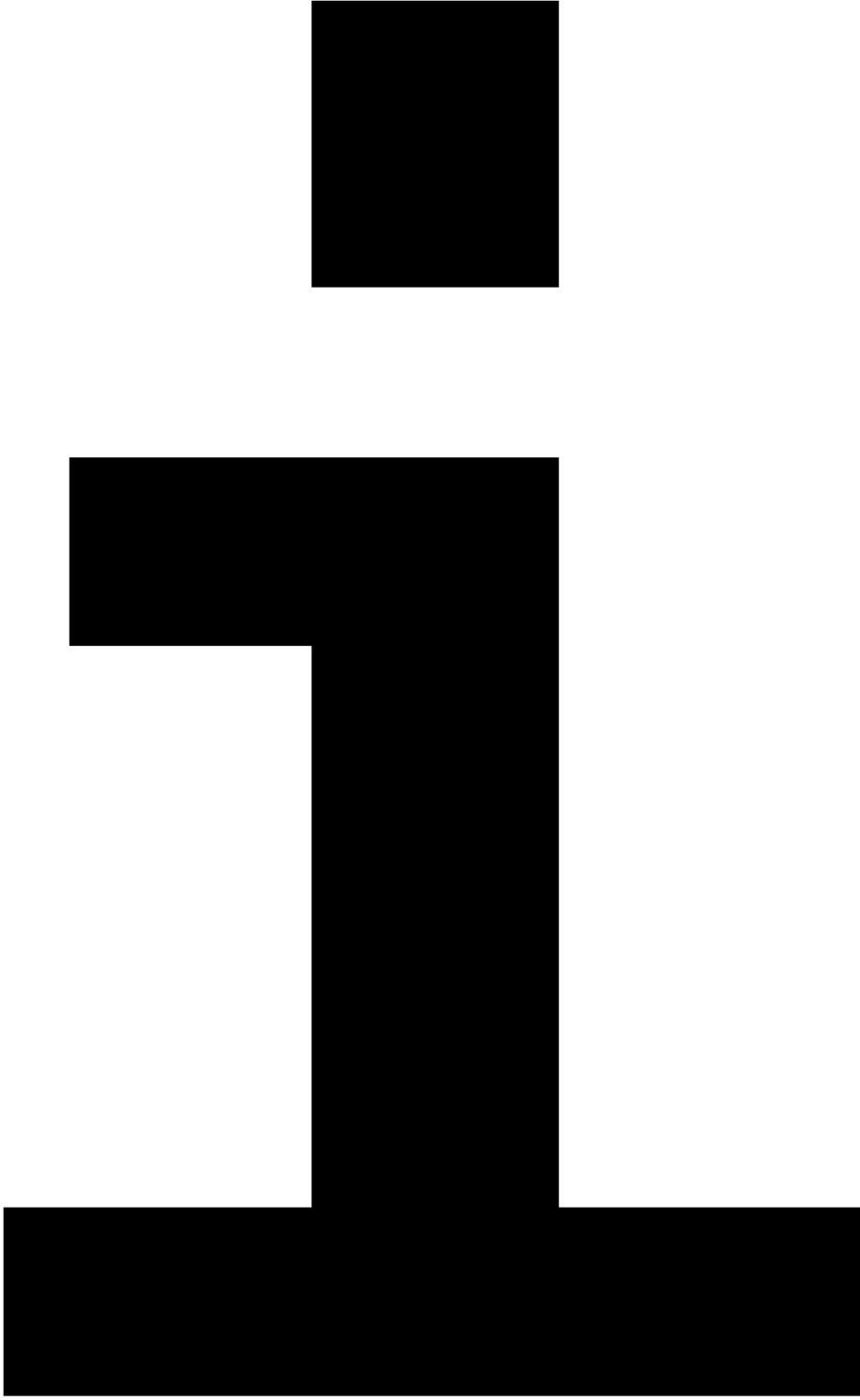
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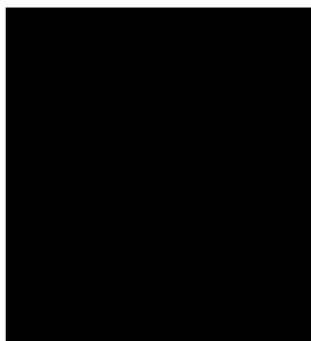
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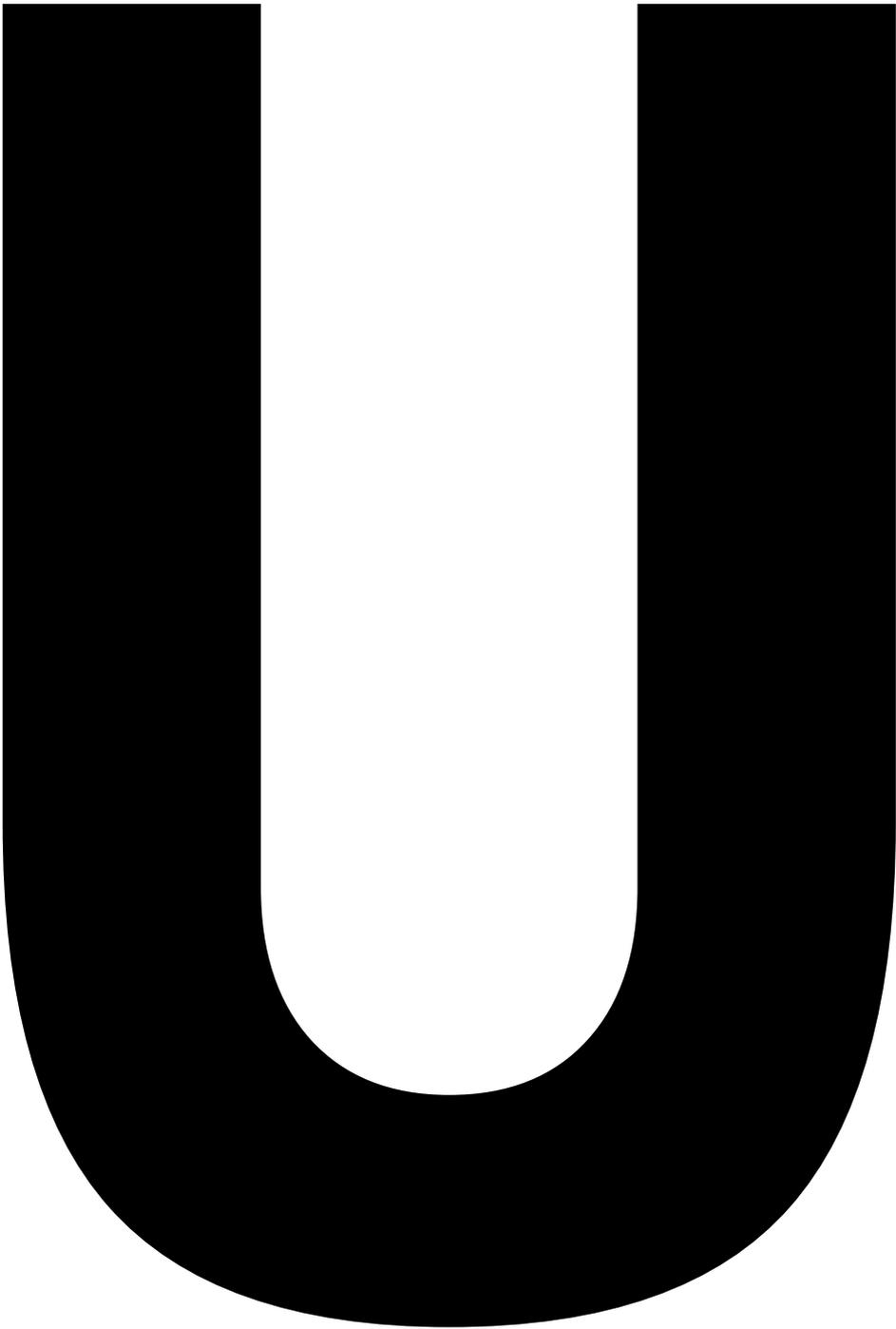
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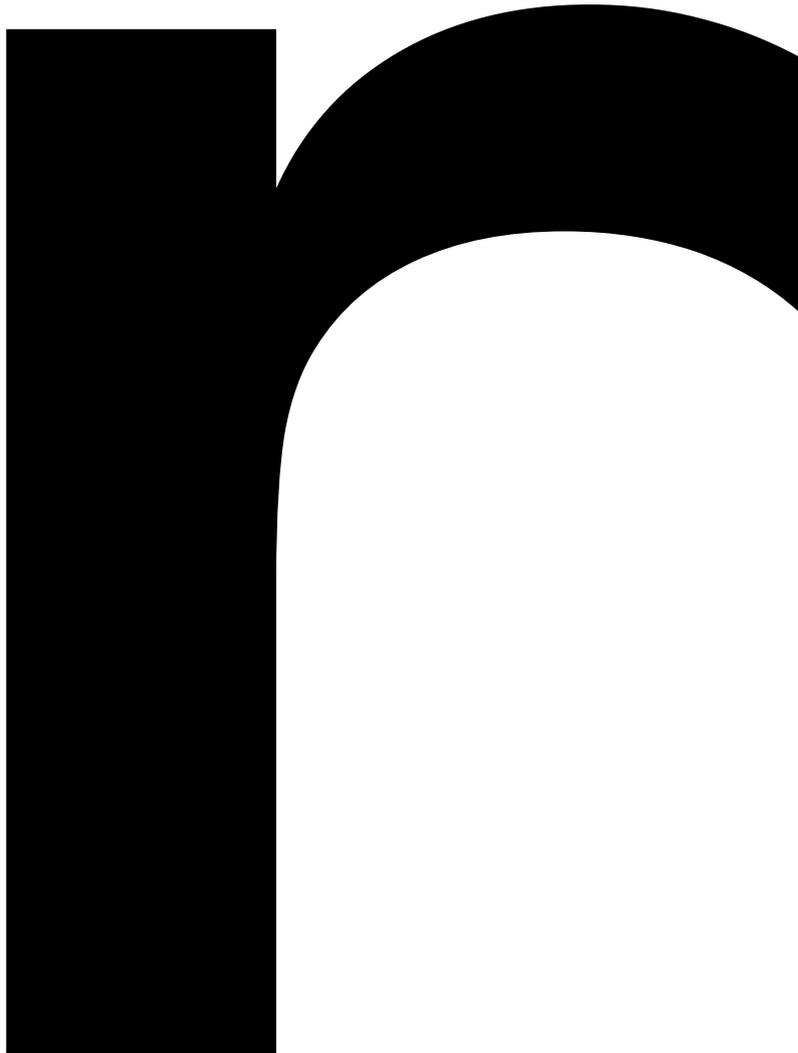
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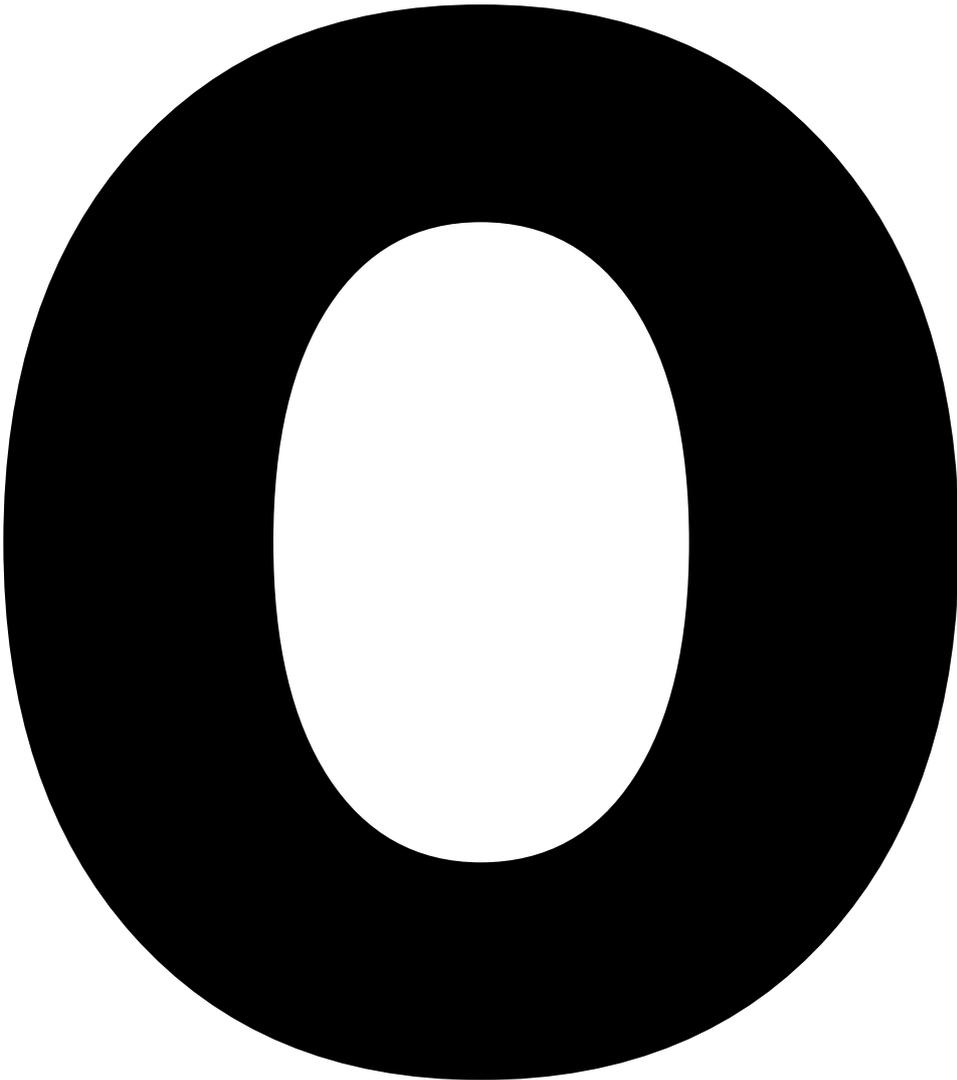


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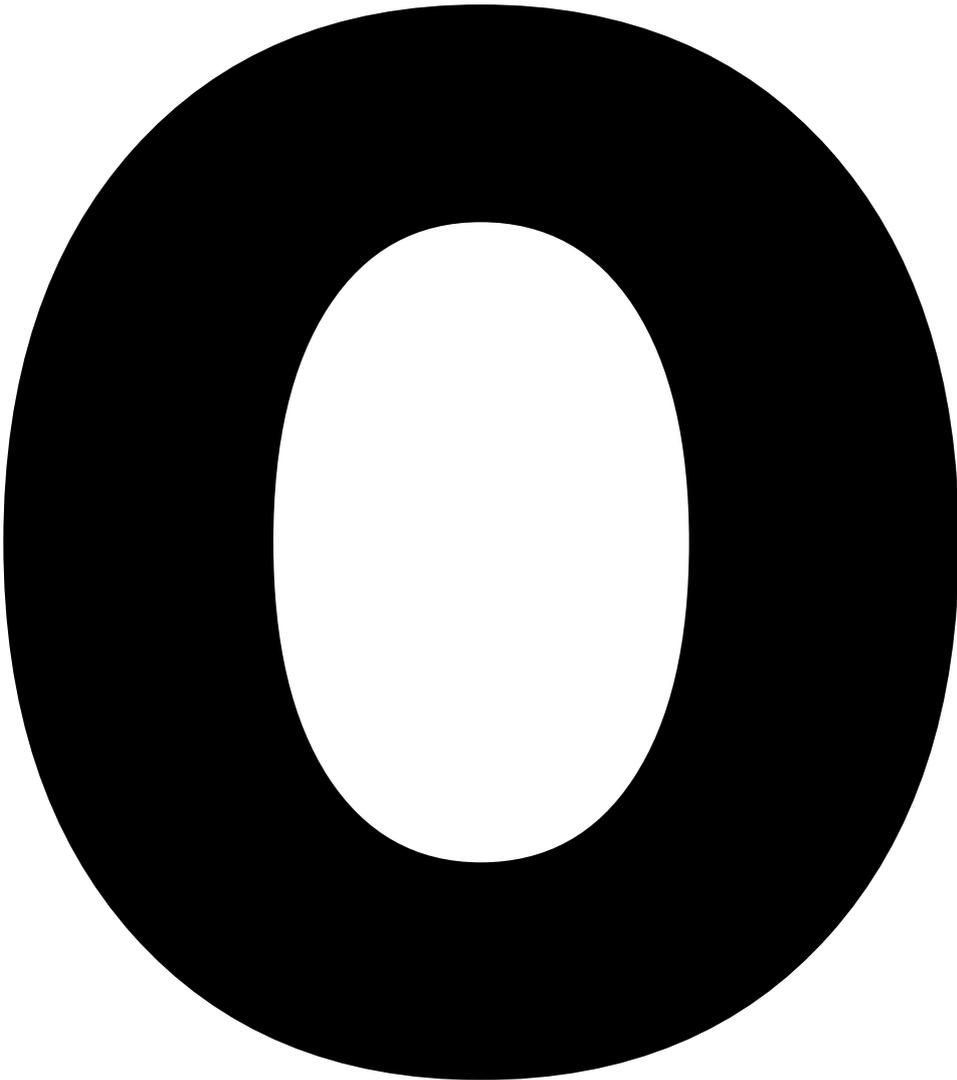
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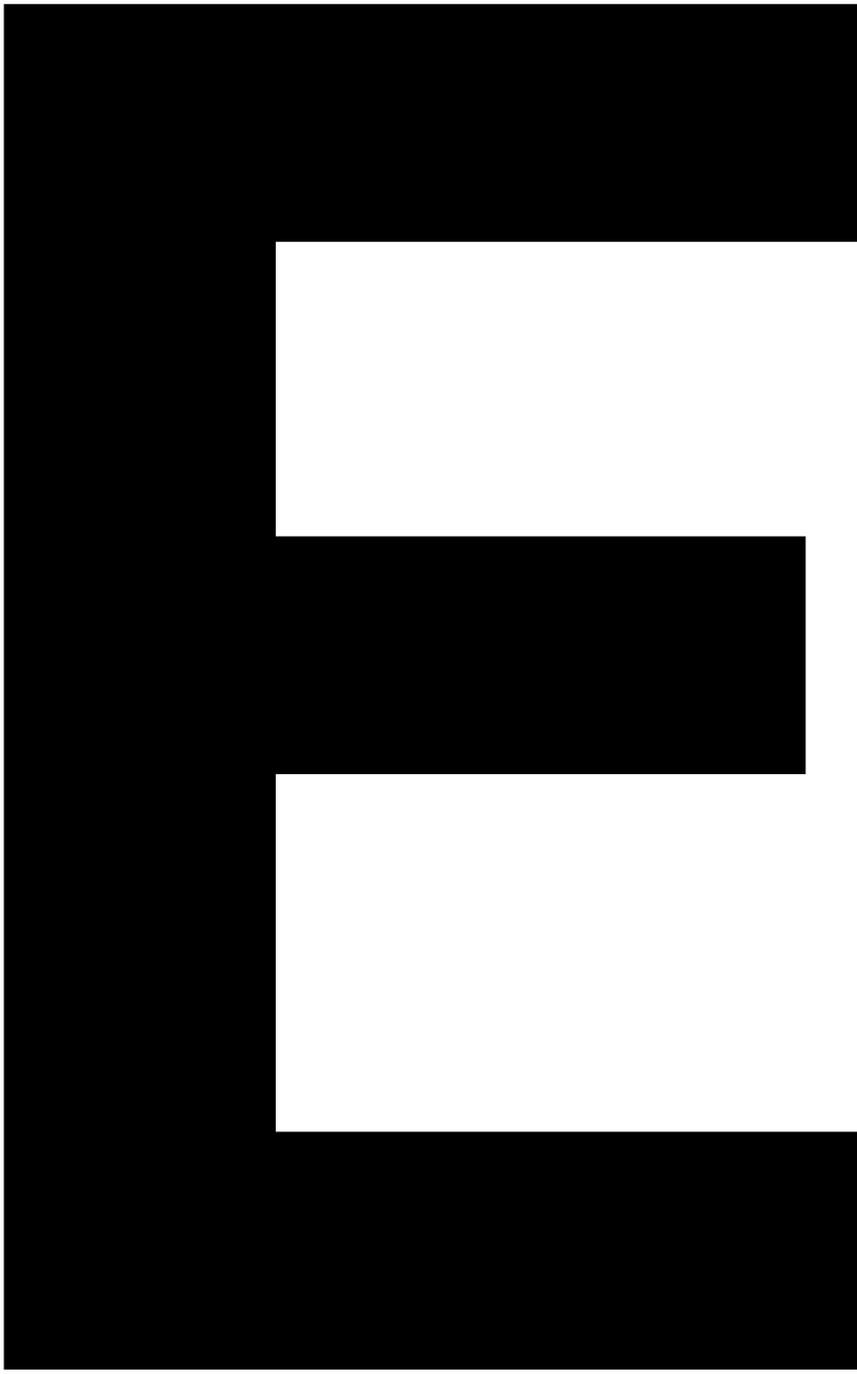


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