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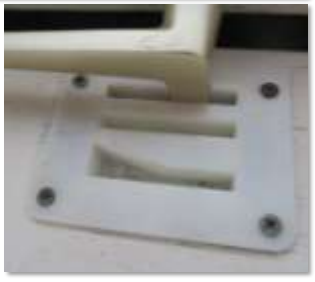
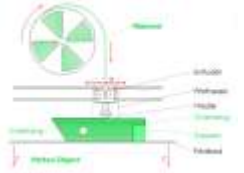
John Broere
Lia Franke

Wat kan je allemaal printen?



Wat komt er aan bod?



- Ontstaan van de 3D-printer
- Werking 3D-printer
- In 5 stappen naar een resultaat:
  - 3D-model creëren
  - naar printbaar formaat omzetten
  - printer voorbereiden
  - printen
  - nabehandelen
- 3D-printer demonstratie

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Van professioneel naar hobby

Professioneel

Hobby

Duplicator i3 mini

Prusa

Delta

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Een bijzondere 3D-printer

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Ontstaan van de 3D-printer

- Technologie voor 3D-printers:
  - **Stereolithography** (**STL-bestanden** voor 3D-modellen afgeleid)
  - **Fused deposition modeling (FDM)** (werkingsprincipe hobby 3D-printers)
  - **SLA printing**
  - Powder bed inkjet printing
  - Selective laser sintering
  - Enzovoort
- Technologie voor CNC-machines:
  - Computergestuurde frees- en draaibanken
  - Werken met G-codes (hiervan zijn de **G-codes** voor de 3D-printers afgeleid)

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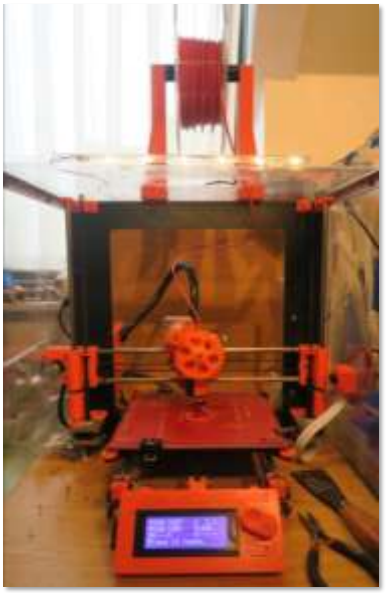
Hobby 3D-printers

Doorbraak door het RepRap initiatief in 2004:

- Concept van zelfreproductie (Replicating)
- Open Source ontwikkelingen hardware en software
- 2009: eerste commerciële model
- RepRap modellen werden de basis voor huidige FDM-consumentenprinters
- 2012: Prusa komt met verbeterde RepRap-versie



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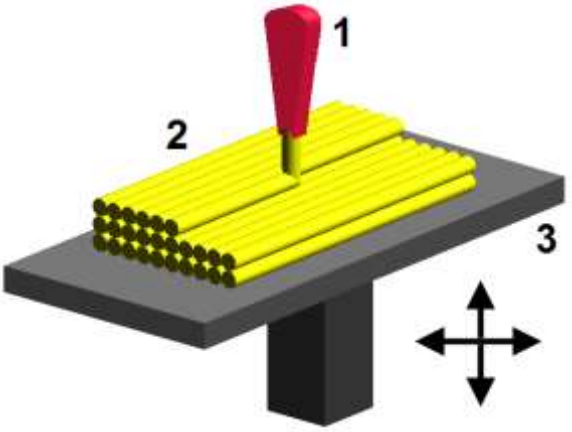
Printtechniek: laag voor laag printen



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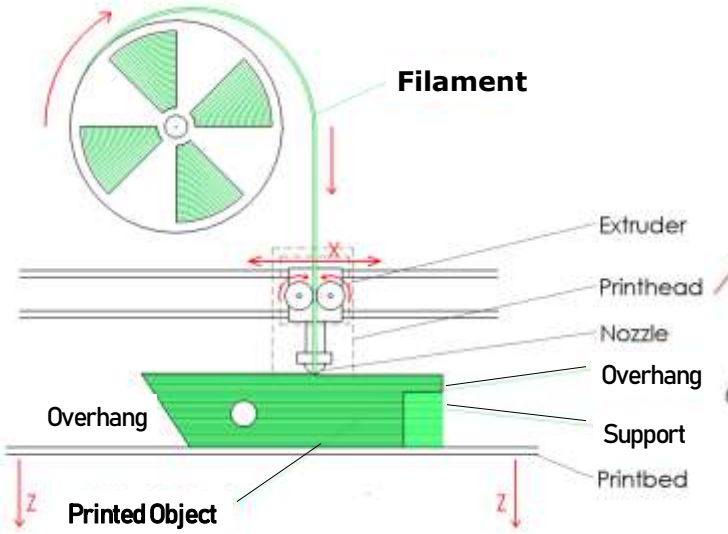
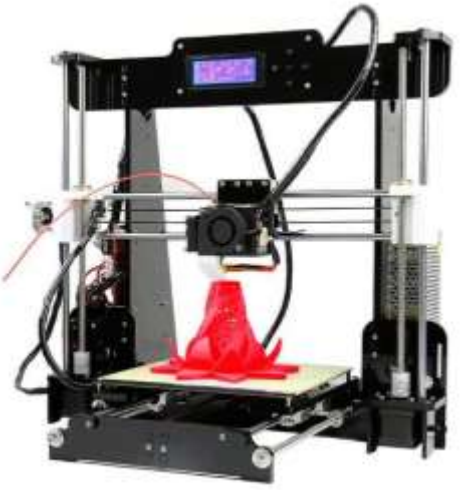
Werking 3D-printer





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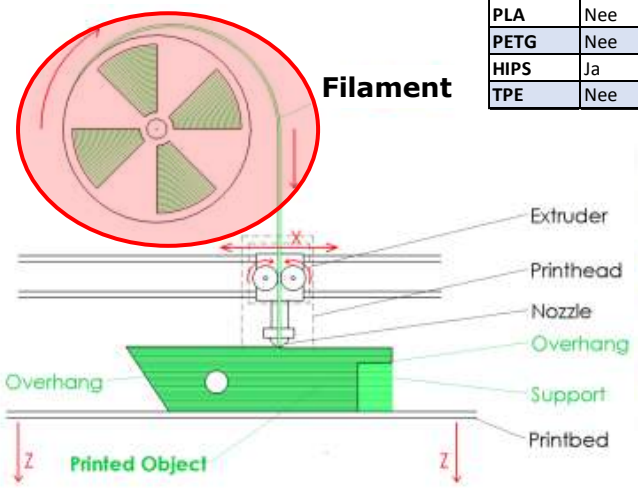
Filament

Materiaal	verwarmd bed	temperatuur	eigenschappen
ABS	Ja	220°C - 260°C	sterk, hittebestendig
PLA	Nee	180°C - 230°C	scherpe details, glans, hoge printsnelheden
PETG	Nee	230°C - 250°C	zeer sterk, hoge printsnelheden
HIPS	Ja	220°C - 260°C	licht en sterk, oplosbaar
TPE	Nee	210°C - 235°C	zeer flexibel, slijtvast



Diameters:
- 3 mm (2,85 mm)
- 1,75 mm

Prijs:
- vanaf 25 €/kg

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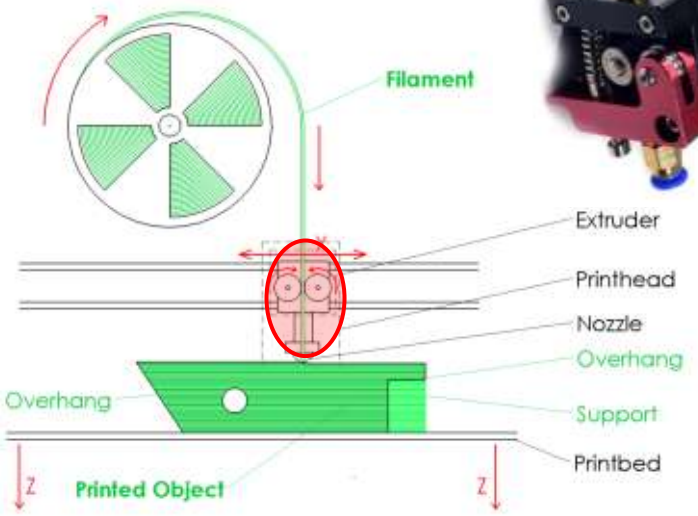
Extruder / nozzle



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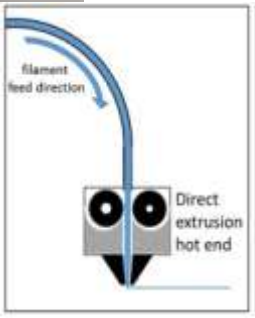
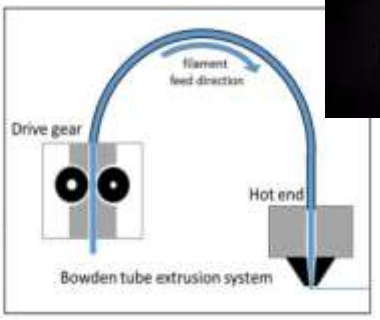
Extruder: Direct Feed of Bowden Tube





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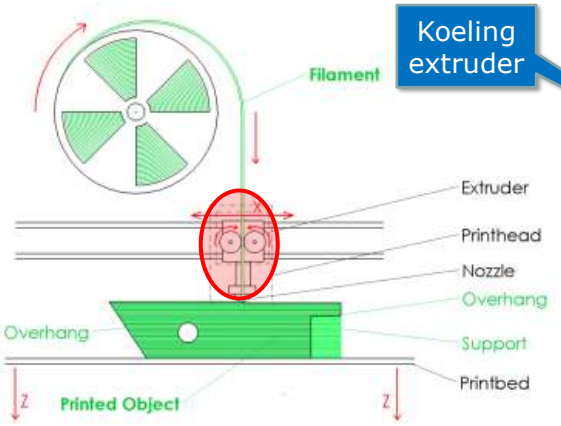
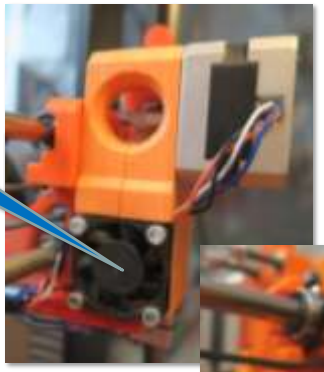
Ventilatoren



Koeling extruder



Koeling object

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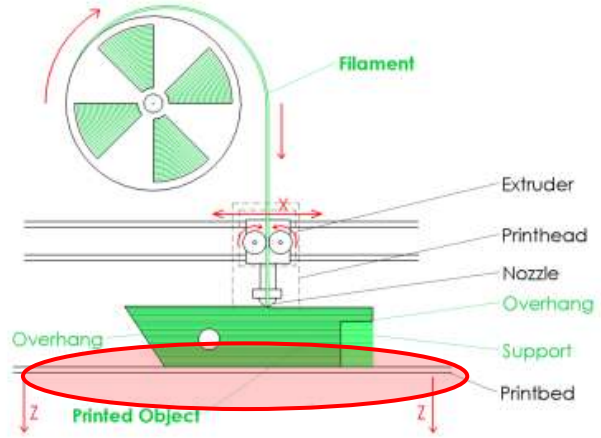
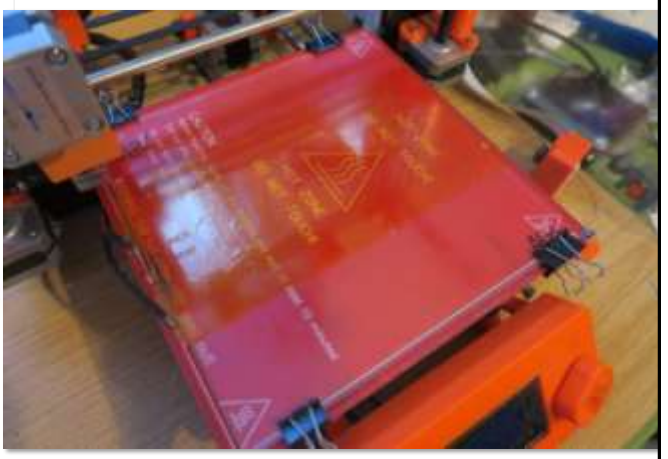
Printbed





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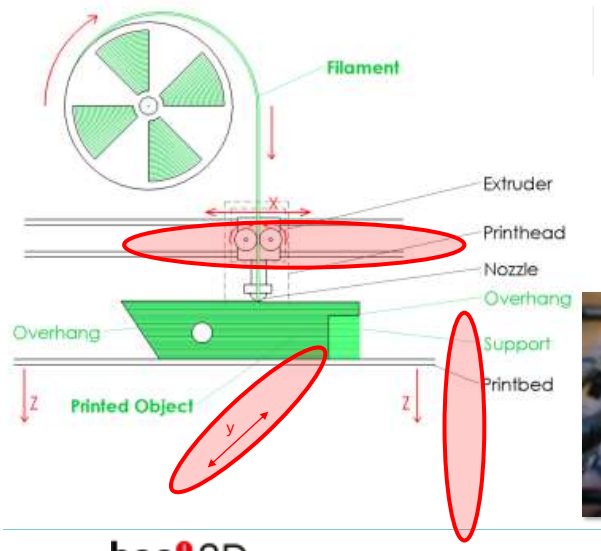
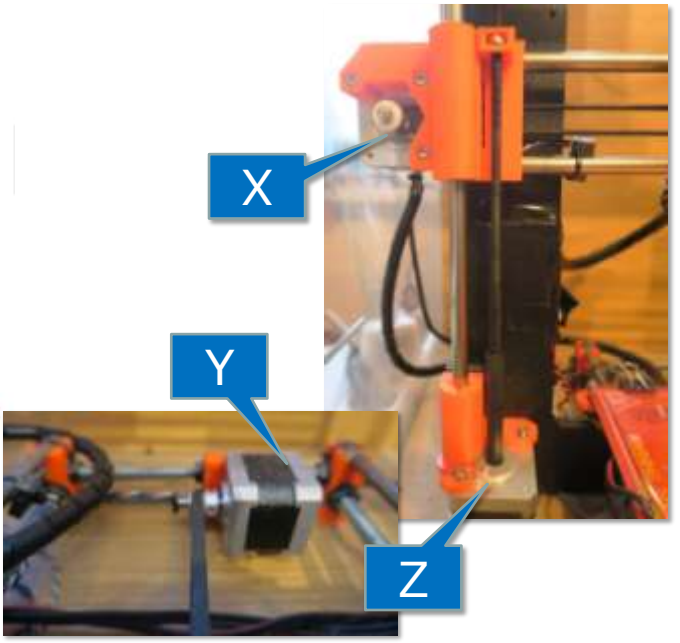
X-Y-Z verplaatsing





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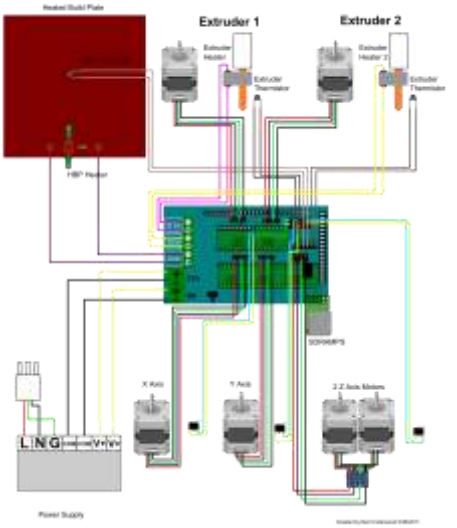
Besturing: Hardware

Arduino + RAMPS

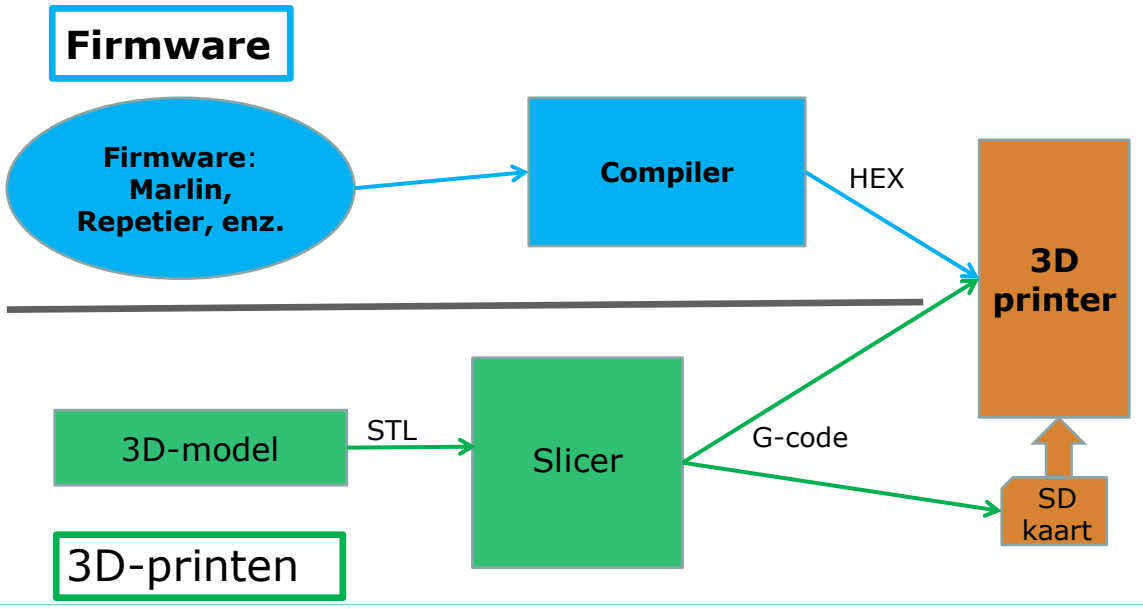
- X, Y, Z stappenmotoren
- Extruder motor
- Extruder heater
- Printbedverwarming
- Ventilatoren

RepRap Arduino Mega Pololu Shield 1.4



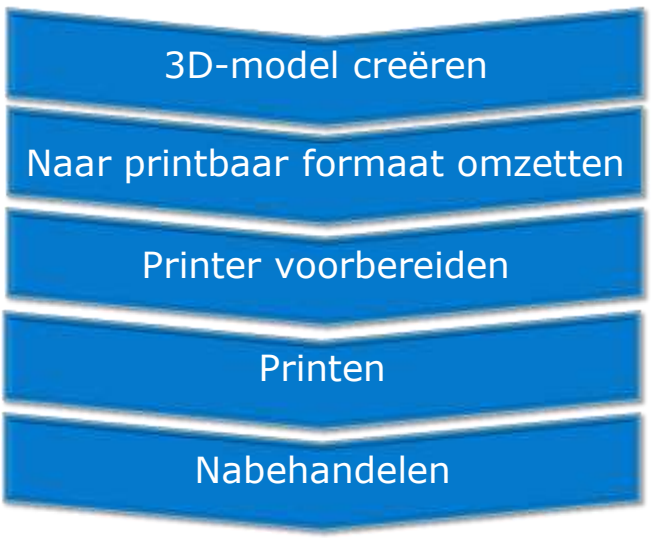
hcc 3D

hcc

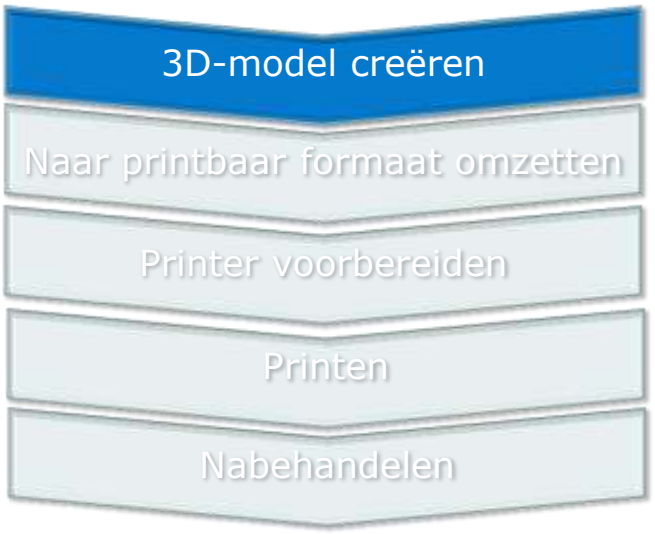


hcc 3D hcc

In 5 stappen naar resultaat



hcc 3D hcc



3D-model creëren

- a. kant-en-klaar van internet
- b. 3D-Scanner
- c. 3D-Sculptuur
- d. 3D-CAD-ontwerpen

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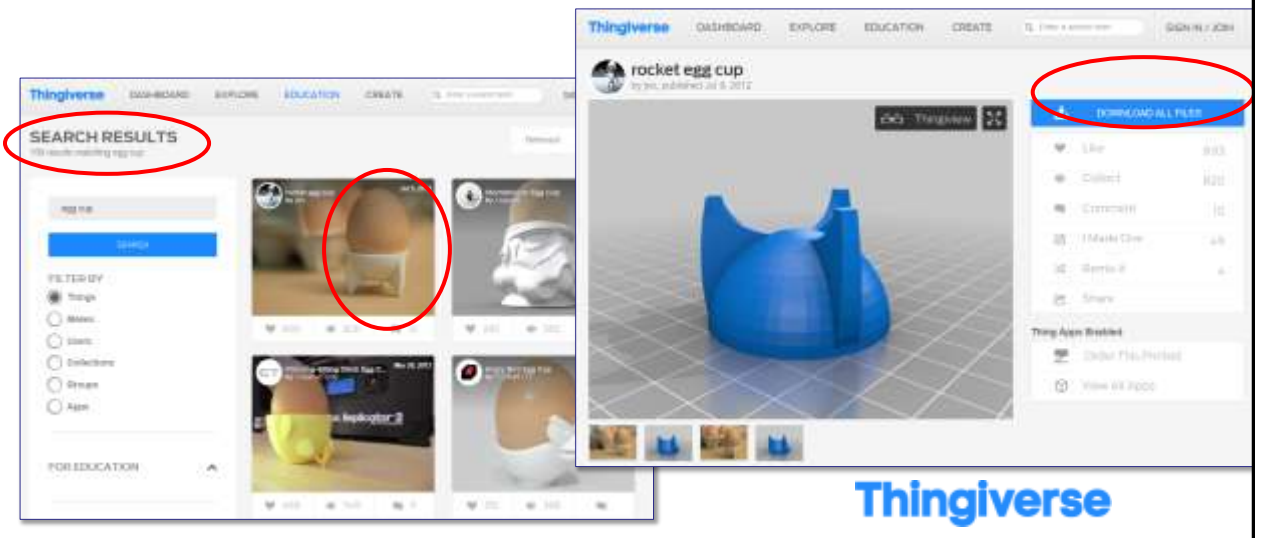
kant-en-klaar van internet
Modellen op het web: Thingiverse, Instructables



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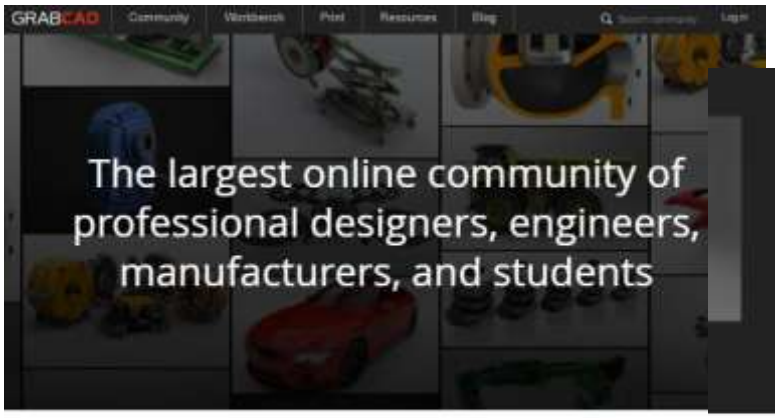
Modellen op het web: GrabCAD



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Scannen: 3D-camera

Kinect

Intel D415

RepRap Ciclop

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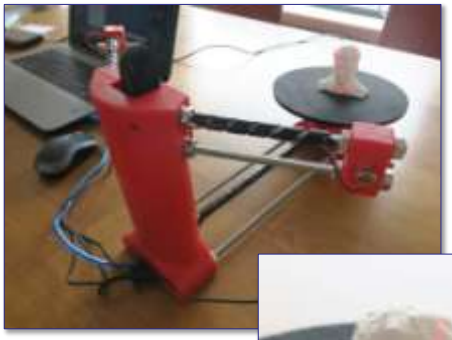
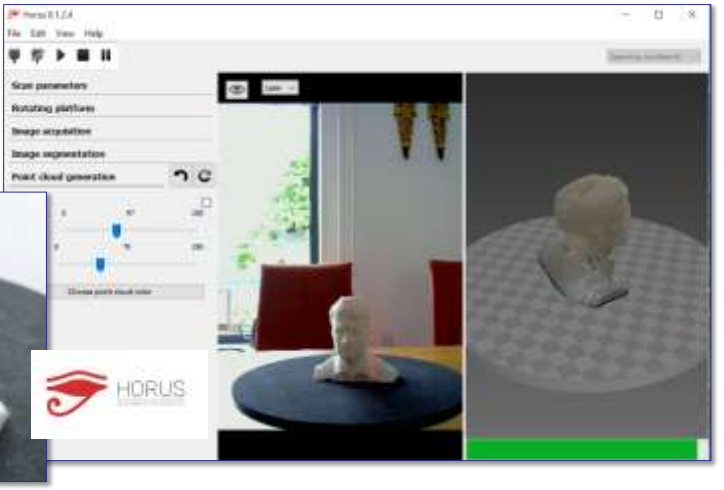
Scannen: 3D-camera en kleine objecten



Ciclop



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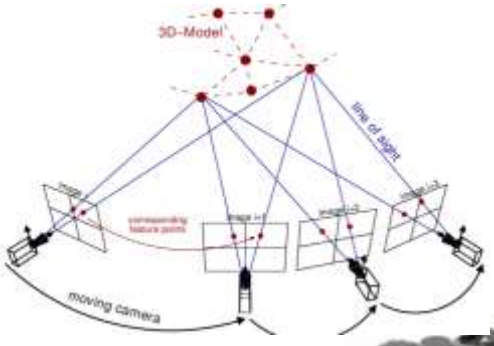
Scannen: Fotogrammetrie (Structure from Motion)



Gewone camera,
smartphone,
of dronecamera

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Scannen: Fotogrammetrie

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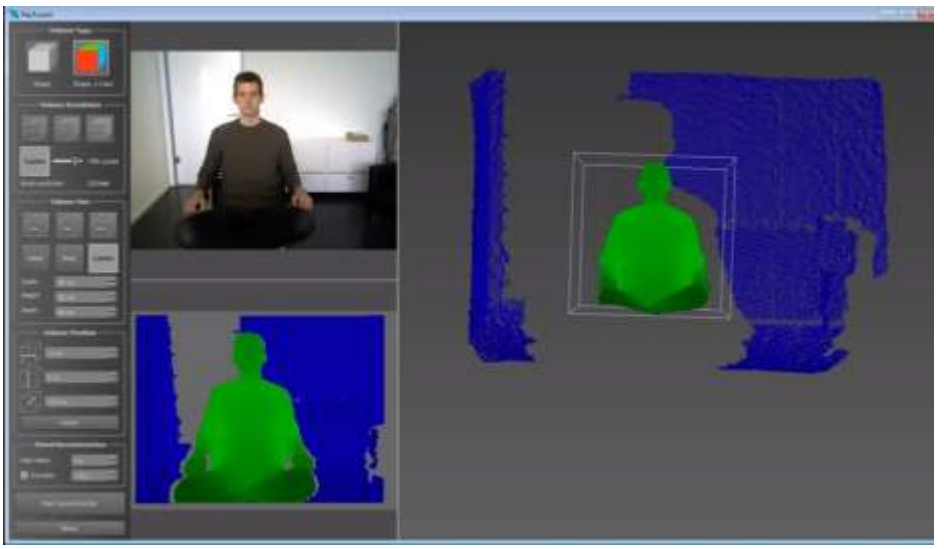
Software: RecFusion, Skanect, enz.



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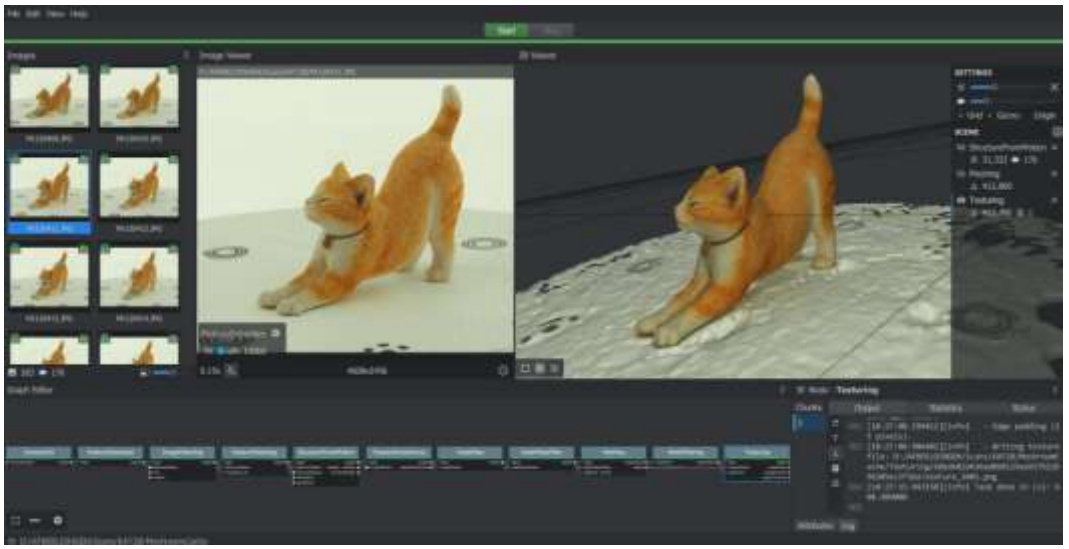
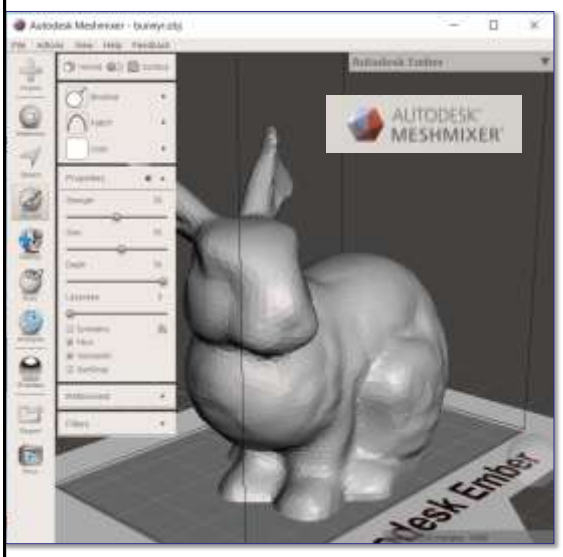
Software: Meshroom, Regard3D



hcc 3D

hcc

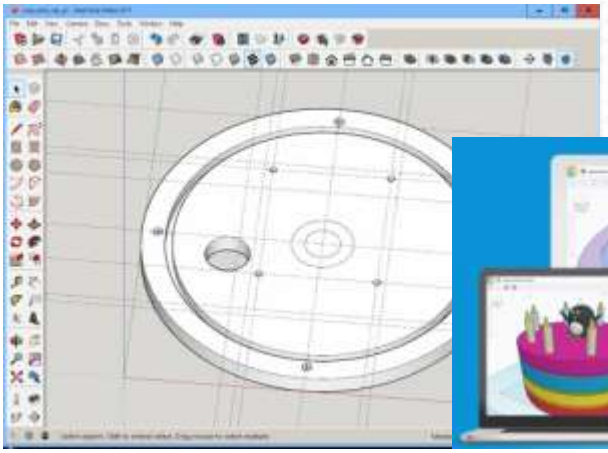
Sculpturen maken



hcc 3D

hcc

3D-CAD ontwerpen



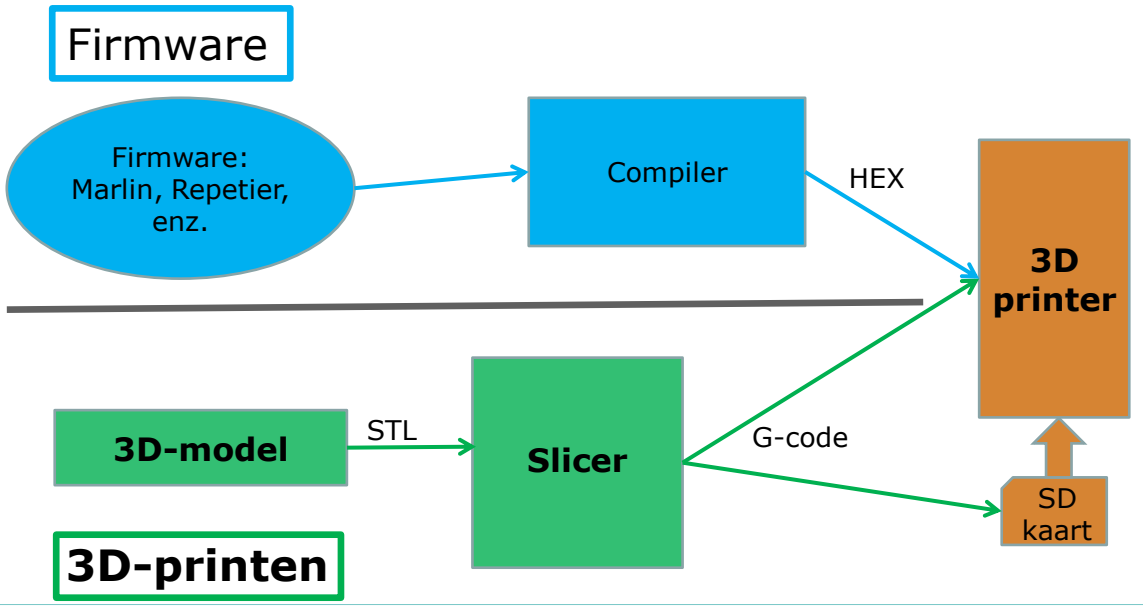
TINKERCAD

hcc 3D

hcc

hcc 3D

hcc

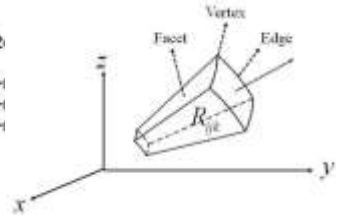


hcc 3D

hcc

Verschil STL en G-code

```
solid Default
  facet normal -7.674352e-17 4.092988e-16 -1.000000e+00
    outer loop
      vertex -6.188052e+01 1.340267e+01 0.000000e+00
      vertex 5.535887e+01 -1.774595e+01 2.775558e-15
      vertex -5.089209e+01 -3.972281e+01 0.000000e+00
    endloop
  endfacet
  facet normal -7.674352e-17 4.092988e-16 -1.000000e+00
    outer loop
      vertex 5.535887e+01 -1.774595e+01 2.775558e-15
      vertex -6.188052e+01 1.340267e+01 0.000000e+00
      vertex 4.437044e+01 3.537954e+01 2.775558e-15
    endloop
  endfacet
  facet normal -7.674352
    outer loop
      vertex -3.383593e+
      vertex -3.497938e+
      vertex -3.607280e+
    endloop
  endfacet
```




```
;LAYER:
M106 S25
G0 F9000 X117.715 Y100.584 Z0.400
G0 X114.576 Y100.400
G0 X113.537 Y99.396
;TYPE:FILL
G1 F1320 X113.058 Y98.997 E75.54222
G1 X113.469 Y98.641 E75.55127
G0 F9000 X113.459 Y98.287
;TYPE:WALL-INNER
G1 F1320 X113.536 Y98.357 E75.55301
G1 X113.565 Y98.396 E75.55382
G1 X113.630 Y98.534 E75.55636
G1 X113.698 Y98.
G1 X113.730 Y99.
G1 X117.779 Y99.
G1 X117.670 Y98.
G1 X117.646 Y98.
G1 X119.447 Y98.
G1 X119.447 Y105
G1 X123.495 Y105
```

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Naar printbaar formaat omzetten:
van *STL* naar *G-code*

Model
(STL file)

Slicer

- Model oriëntatie op het printbed
- Print instellingen
- Filament instellingen
- Printer instellingen

Printer instructies

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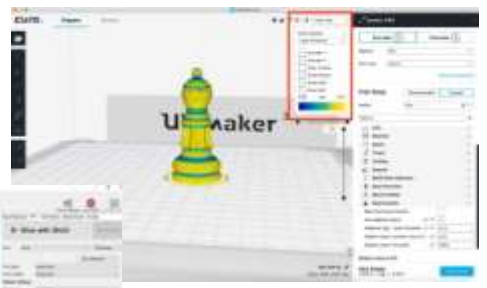
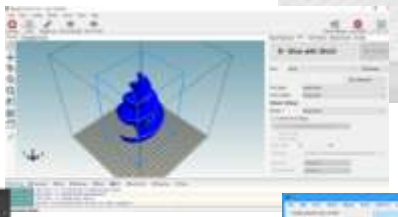
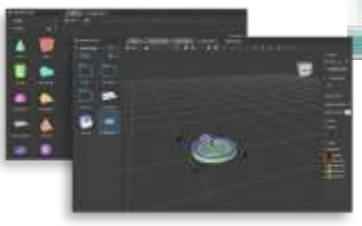
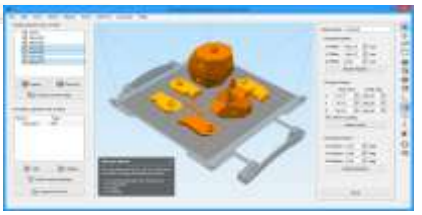
Slicersoftware

- ***Cura***
- ***PrusaSlicer***
- ***MatterControl***
- ***Simplify3D***
- Enz.









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Slicen 3D-model

Laad STL
(3D-model)
- Oriëntatie
- Aantal
- Schaal

Printer settings
- Printbed
- Nozzle diameter
- Retraction
- Start-, End G-codes

Filament settings
- Diameter
- Temperatuur
- Koeling
- Soort filament

Print settings
- 11Lagen
- Wanddikte
- Infill
- Skirt / Brim
- Support
- Snelheid

Export G-code

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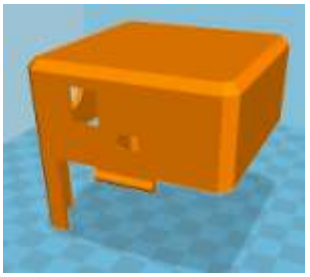
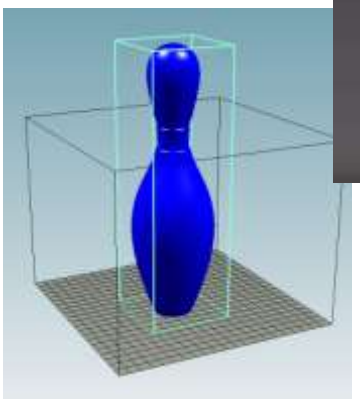
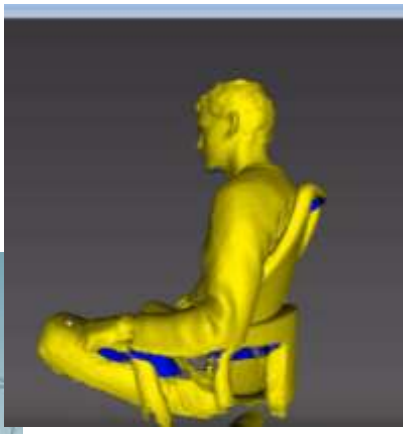
Slicen

- Laden STL: waterdicht?
- Past het 3D-model op het bed?
- Oriëntatie op het printbed OK?







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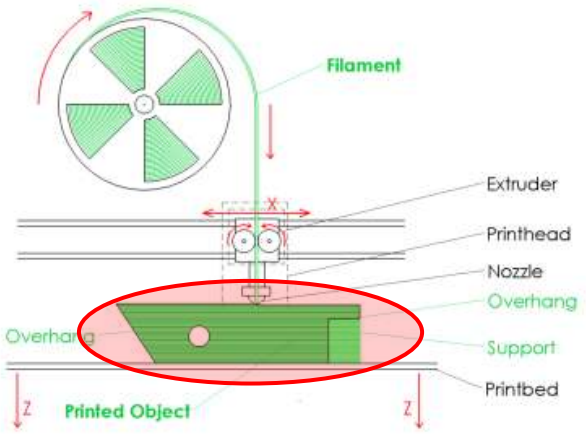
Slicen



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Printer voorbereiden

- Printbed levelling
- Printbed voorbereiden
- Verwarmen extruder/nozzle
- Filament doorvoeren
- Printfile laden:
  - sd-card
  - usb-kabel
  - Octoprint

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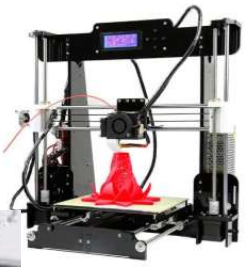
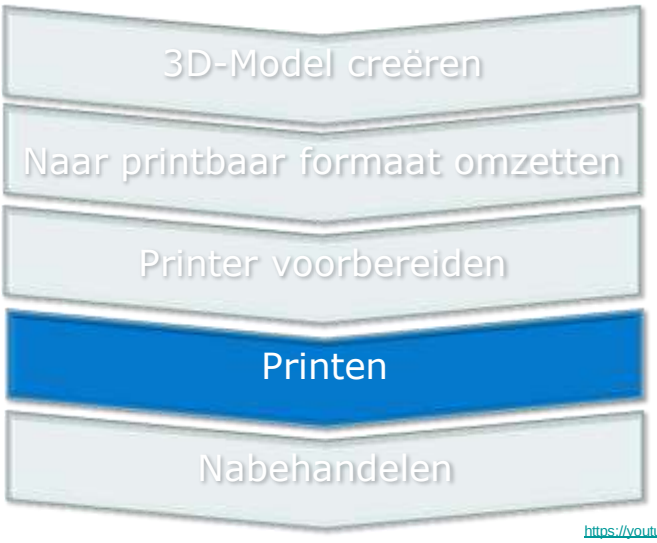
Printkwaliteit

- **3D-printer**
- **Afstelling 3D-printer**
- **Slicerinstellingen**



hcc 3D

hcc



https://youtu.be/K-fA5EsYi0E?list=PLU2yo5Nj-xmlliSemEtAmi8TIlX8xjJdV

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Mogelijke printproblemen

- Geen materiaal eerste laag
- Slechte hechting op het bed / loslaten
- Kromtrekken (warping)
- Omvallen van smalle structuren
- Ruwheid van het oppervlak
- Slechte hechting tussen lagen
- Vastlopen filament
- Filamentbreuk
- Verstopping extruder

Belangrijkste tips:
1. Gebruik goed filament
2. Zorg voor goede voorbereiding en kalibratie van het printbed
3. Experimenteer met instellingen

Ruw oppervlak

Warping

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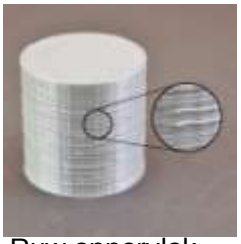
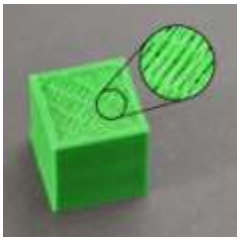
Printproblemen?


Ruw oppervlak


Kromme hoeken


Draden


Kromtrekken

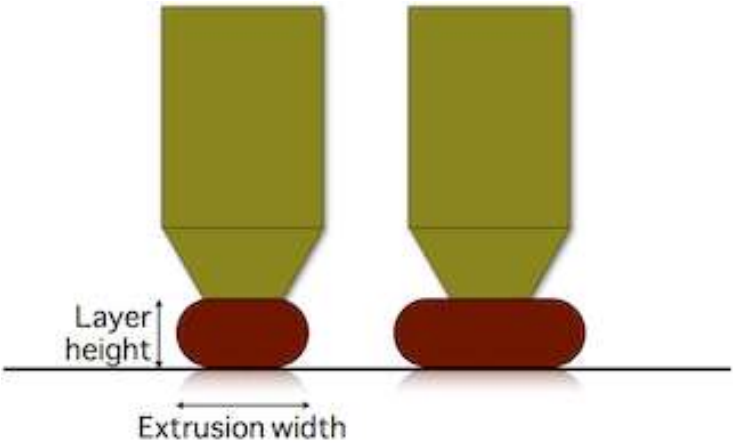

Gaten in toplaag

Gaten in dunne wanden

hcc 3D

hcc

Eerste laag



hcc 3D

hcc

hcc 3D

hcc

Nabehandelen

- Print van printbed halen en contactvlak schoonmaken
- Support en brim verwijderen
- Eventuele kleine correcties met soldeerpistool
- Separaat geprinte onderdelen verlijmen
- FDM prints hebben een vrij ruw oppervlak. Desgewenst glad en glanzend te maken door schuren/polijsten

hcc 3D

hcc

Klaar!

- 3D-model creëren
- Naar printbaar formaat omzetten
- Printer voorbereiden
- Printen
- Nabehandelen

hcc 3D

hcc

En nu printen?

- 3D-printers al minder dan 300 euro
- Rol PLA (1 kg) vanaf 25 euro
- Veel open source software (dus gratis)
- Kennisuitwisseling via HCC interessegroepen 3D
- Breed toepasbaar

hcc 3D

hcc