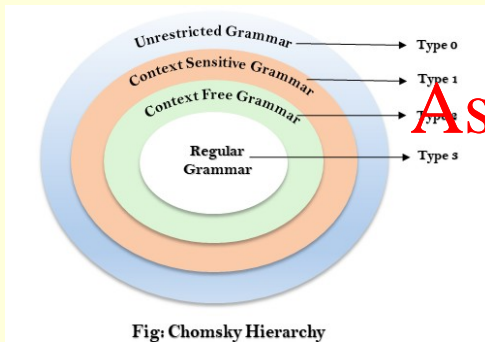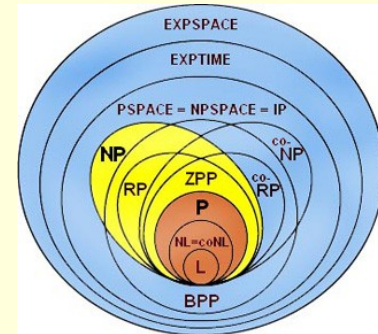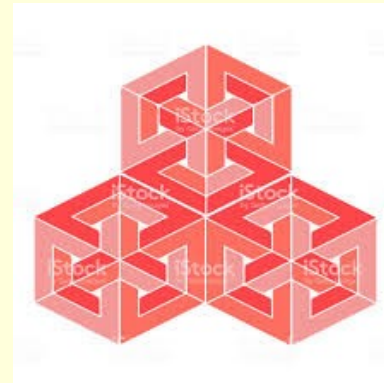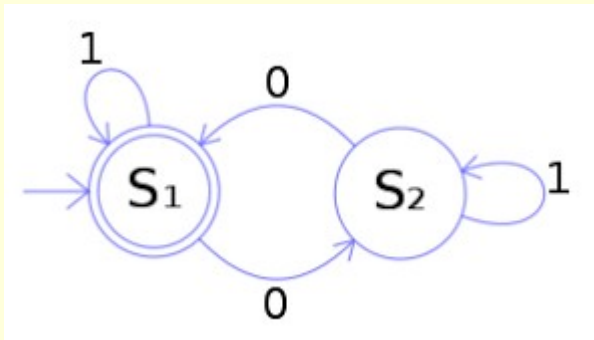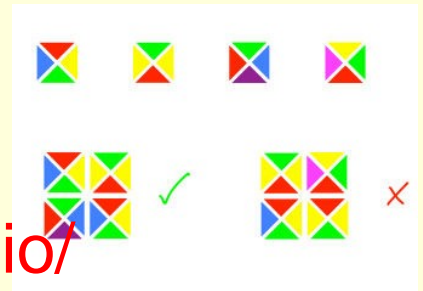# COSC1107 Computing Theory

(We will commence soon. We are just allowing a few minutes for people to join and set up. *Please mute your microphone unless you are speaking.* You can raise your hand or use the chat at any time.)
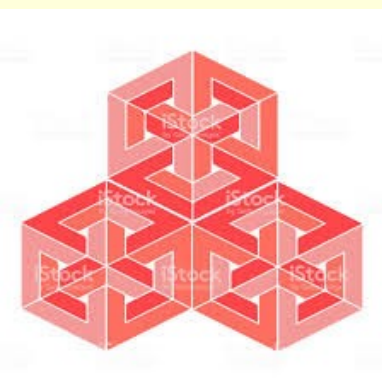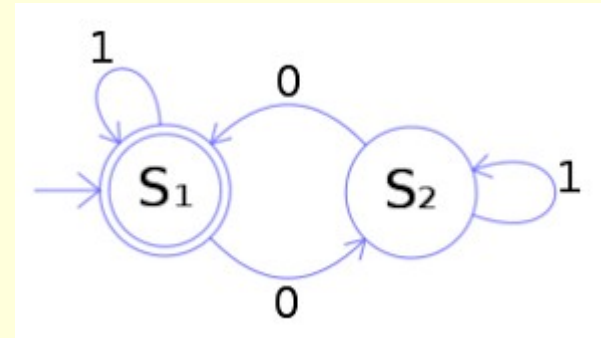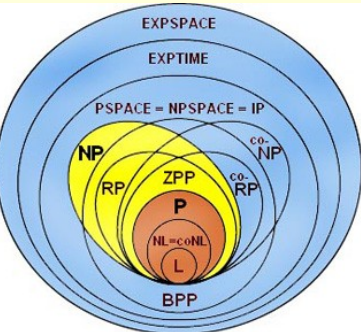

Fig: Chomsky Hierarchy

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COSC1107

C   ry
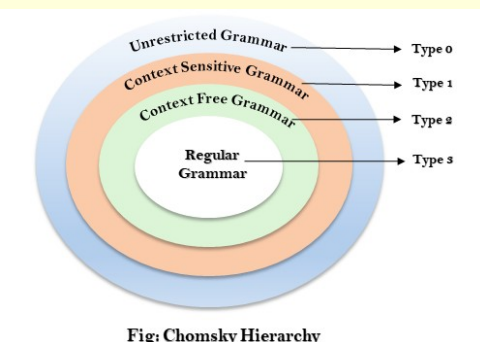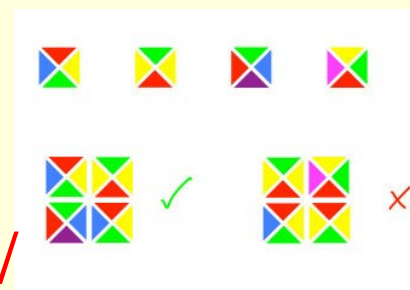
Week

James Harland

james.harland@rmit.edu.au

* With thanks to Sebastian Sardina

Intro music 'Far Over' playing now …

EXPSPACE
EXPTIME
PSPACE = NPSPACE = IP
NP
co-NP
RP ZPP co-RP
P
NL=coNL
L
BPP

Unrestricted Grammar → Type 0
Context Sensitive Grammar → Type 1
Context Free Grammar → Type 2
Regular Grammar → Type 3

Fig: Chomsky Hierarchy

Computing Theory

Acknowledgement

RMIT University acknowledges the people of the Woi wurrung and Boon wurrung language groups of the eastern Kulin Nations on whose unceded lands we conduct the business o University respectfully ac stors and Elders, past and present

RMIT also acknowledges the Traditional Custodians and their Ancestors of the lands and waters across Australia where we conduct our business.

(add your name here to volunteer for this or email me)
(my personal Acknowledgement of Country is here)

Computing Theory

Acknowledgement

As we gather virtually, from all areas around South Central Victoria, we acknowledge the people of the Eastern and Western Kulin Nations.

In this time when our Wilam (camp or meeting place) is dispersed across many separat~~e~~ all feel a strong sense of Noogal (belonging ~~colle~~agues, friends, and family using alternative and accessible communication methods.

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Add WeChat edu_assist_pro

We acknowledge that the lands we are conducting our business today remains unceded. We respectfully acknowledge the first nations people of the five Kulin Nations, their Ancestors and Elders, past, present and emerging. (thanks to Nick Balkin for this acknowledgement)

Weekly Schedule

	Lectorial	Tutorial	Assessment
12	**Research and requests**	Sample exercise	**Assignment 2**
14-16	--	--	**Final exercise**

- Quiz 10 deadline is 11:59pm Monday 11ᵗʰ October

- Assignment 2 de **esday 19ᵗʰ October**

- Questions 4b, 4e of Assignmen submitted **via a special quiz on Canvas** (not as part of the PDF report)

- Other questions & csv files to be submitted as files

- Do not use zip files!

Week 12 Computing Theory

Weekly Schedule

	Lectorial	Tutorial	Assessment
12	**Research and requests**	Sample exercise	**Assignment 2**
14-16	--	--	**Final exercise**

Final exercise

- Released at 9.0   **r**
- Due by 9.00am on Friday 5th
- Time is Melbourne time (UTC   __re)
- Expected time spent on the task is 4-6 hours
- Sample exercise will covered in tutorials in Week 12
- An additional practice exercise will be released soon

Week 12   Computing Theory

Questions?

Questions?

Assignment Project Exam Help

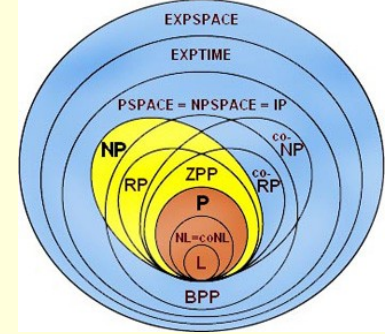https://eduassistpro.github.io/

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Questions?

Requests

Requests for Week 12 class received by Friday 8th October:

Zilch!

Assignment Project Exam Help

Zip!

Zero!

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Nada!

Nothi

Request? What request? I thought you were making the request?

Computing Theory

CES Survey

We want to hear your feedback!

This is your opportunity to tell us about
your experiences related to:

- Assessments
- Methods of teac
- Technology use
- Learning materials

Head to **rmit.edu.au/surveys** to see what
student feedback have helped change in
the past

Deadline is **Sunday 24th October**

Week 12

Computing Theory

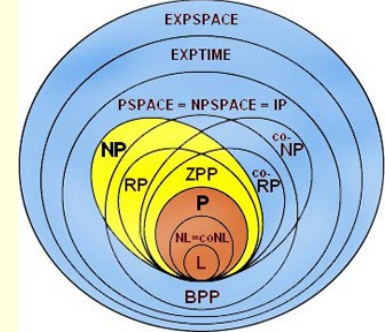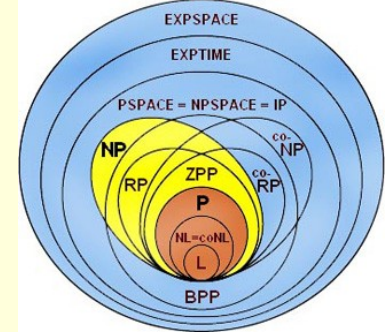Assignment Project Exam Help

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SCAN ME
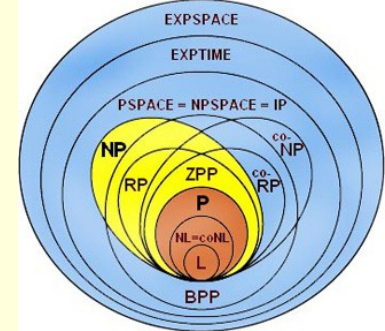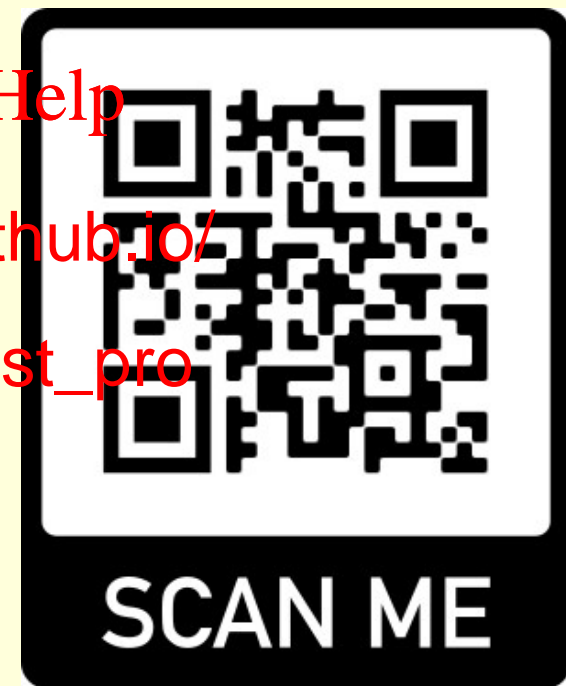
CES Survey

- **Your feedback is important!**

- CES scores are used for evaluation of courses and staff

Assignment Project Exam Help

- Developments in   feedback

https://eduassistpro.github.io/

  - Weekly Quizzes
  - Less assessment Tasks

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  - Design of exercise

- All of these were new for 2021

PLEASE FILL IN YOUR SURVEY!

'Far Over'

Lilypond (from http://lilypond.org/)

- Free "music engraving tool"
- "Programmer's" way to write sheet music
  ("more similar to a programming language than a graphical score editing program")
- Arrangement of Tune
- Generated score
- Generated MIDI t https://eduassistpro.github.io/

```
\header{title = "Far Over …"}

global = {
  \key d \minor
  \time 4/4
  \dynamicUp
}

Tenornotes = \transpose d d \relative c' {
  d,1~d4 r4 a4 c4 d2. f4 g4 a8 (g8) f4 e4 d1~d4
  a4 d4 e4 e1~e4 f4 g4 f8 (e8) d1~d4
  f4 g4. e8 a1~a4 f4 g4. d8 e1~e4
  a,4 c4 e4 f1~f4 g8 (f8) e4 c4 d1
…
```

Week 12   Computing Theory

'Far Over'

Audacity (from https://www.audacityteam.org/)
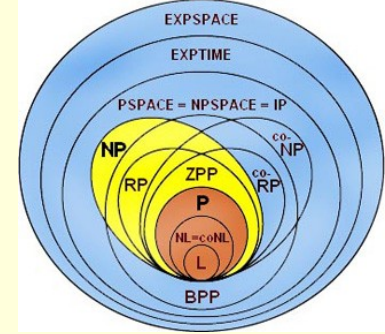
- Free multi-track audio editor and recorder
- Play 'click track' (MIDI version from Lilypond) in headphones
- Sing each indiv~~idual part in time with the click track~~.
- Mix tracks togeth
- Repeat previous tw
- Export project as
- Export project as MP3 (because th

Assignment Project Exam Help

https://eduassistpro.github.io/

iting if need be)

asy to play)

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"Entire choir"

Computing Theory

Questions?

Questions?

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Questions?
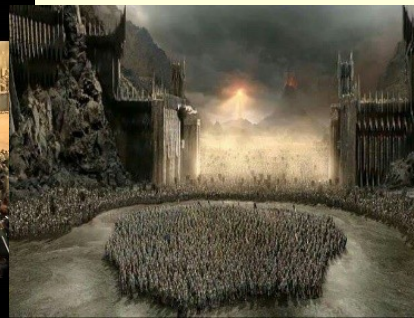
Think music! (This will take 1 minute!)

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Research

- Busy beaver
- Placid Platypus
- Universal TMs
- Platypus Game

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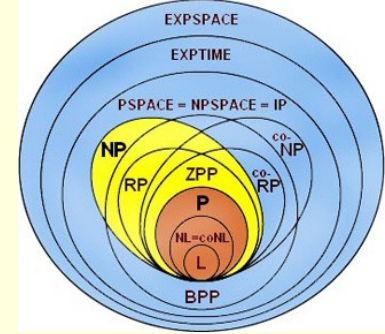
GET READY!

Computable Functions
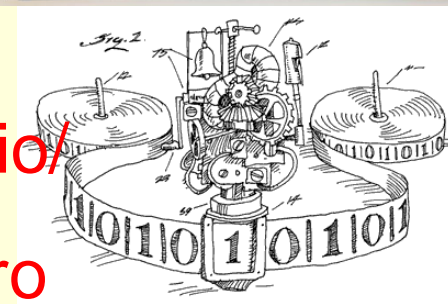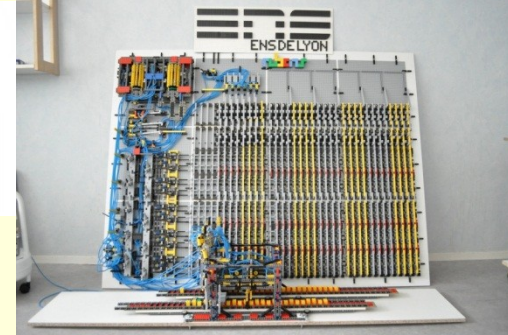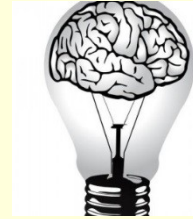
Some functions are not computable!

Turing Machines of a particular type:

- DeterminisAssignment Project Exam Help

- Symbols are o https://eduassistpro.github.io/

- Only consider blank input

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- n states plus a halt state me   n
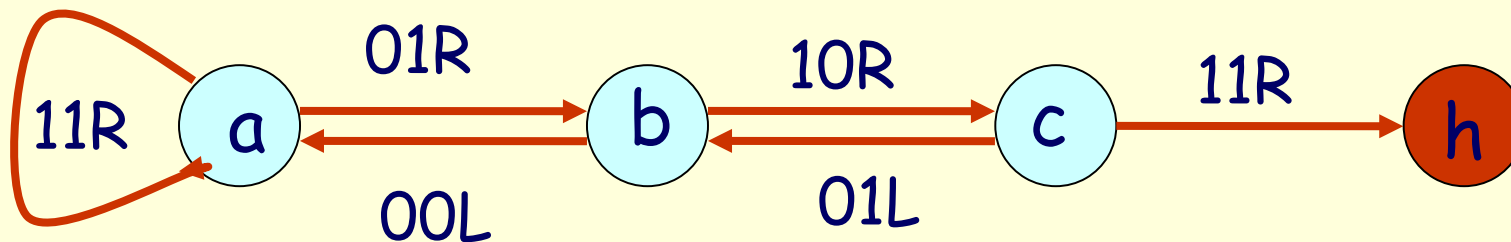
Busy Beaver
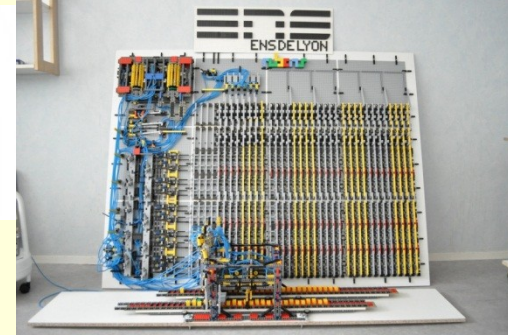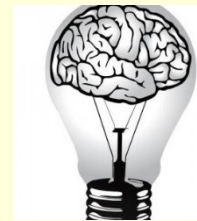
What is the largest number of 1's that can be printed by a terminating n-state machine?

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https://eduassistpro.github.io/

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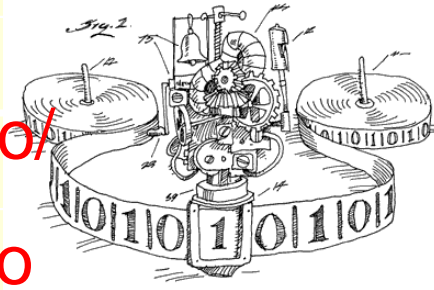
n	#1's (produ	
1	1	
2	4	6
3	6	21
4	13	107
5	≥ 4098	≥ 47,176,870 (??)
6	≥ 3.51×$10^{18,276}$	≥ 7.41×$10^{36,534}$ (!!)

Busy Beaver
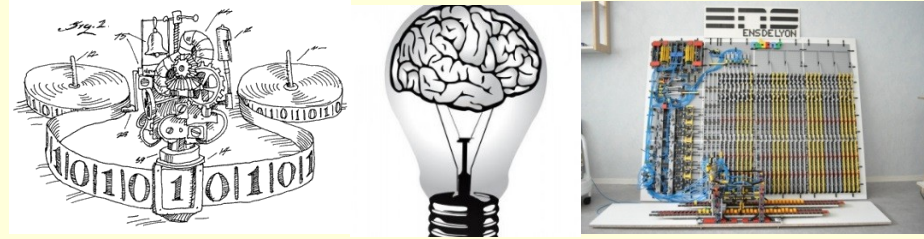
- Busy Beaver function is **non-computable; it grows faster than any computable function (!!)**

- Various mathematical bounds known

- All surpassed in

- Seems hopeless for $n \geq 7$

- Values for $n \leq 5$ seem settled (but as yet unproven)

Week 12

Computing Theory

Busy Beavers

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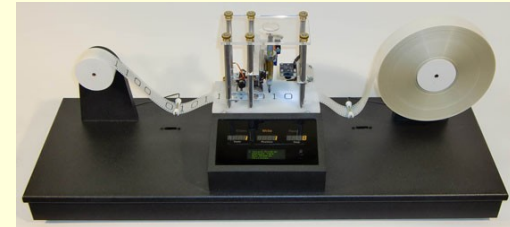
Computing Theory

Busy Beavers
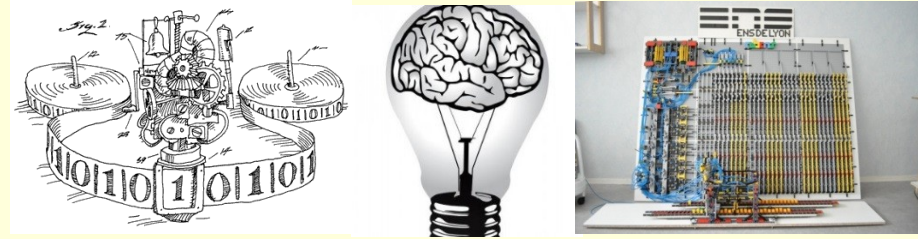
- n = 1,2,3 solved by Lin and Rado in 1960's
- n = 4 solved by Brady in 1970's
  - "proof" unsatisfactory; 200+ cases "checked by hand"

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- n = 5, 6
  - monster m https://eduassistpro.github.io/s and 2000's,
  - proof still not complete
  - Bigger monsters could b Add WeChat edu_assist_pro !_pro

- Much evidence missing and is being re-created

See Heiner Marxen's web page for more

Questions?

Questions?

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Questions?

Busy Beaver Grows FAST!
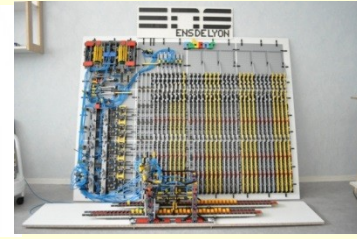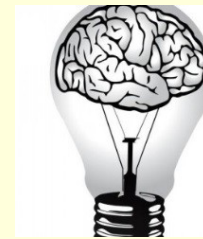
The busy beaver function is non-computable, because it grows faster than any computable function!

Proof: Let f be any computable function.
As f computable,

$$F(x) = \sum_{0 \leq i \leq x} f$$
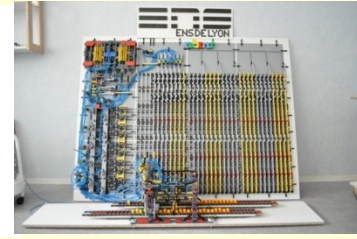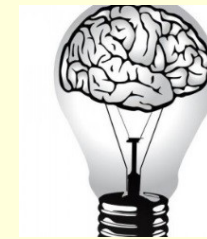
So there is a k-state machine   x) 1's
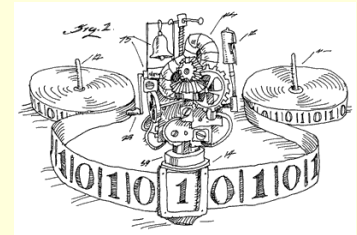
Consider M: X then MF then MF where X: blank → x 1's.
Note X has x states.
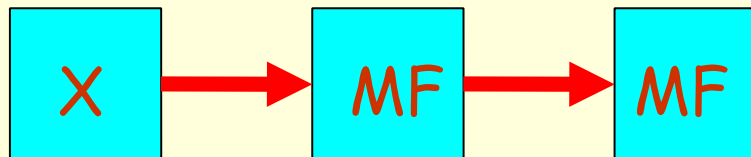
Busy Beaver Grows FAST!

M behaves as follows:

- M first writes x 1's
- M mimics MF, writing F(x) 1's on the tape
- M mimics MF   's on the tape
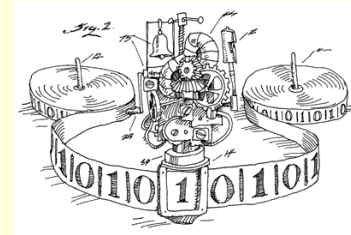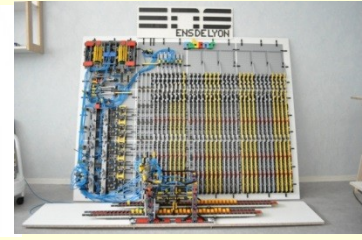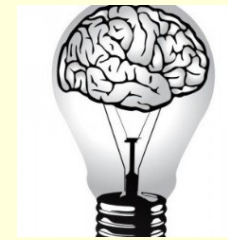
M has x + 2k stat

bb(n+2k) ≥ 1's output by M = x + F(x)) > F(F(x)

Now F(x) ≥ x² > x + 2k for x > m, and F(x) > F(y) when x > y,
and so F(F(x)) > F(x+2k) > f(x+2k)

So bb(x+2k) ≥ x + F(x) + F(F(x)) > F(F(x)) > F(x+2k) > f(x+2k)

Busy Beaver Grows FAST!

This means that bb(n) grows faster than any computable function (!)
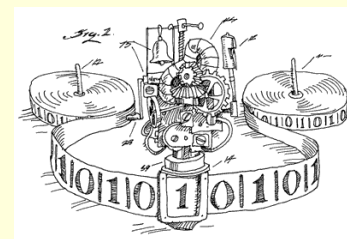
Hence bb(n) is not computable

$n^{n!}$ + 12 is computa

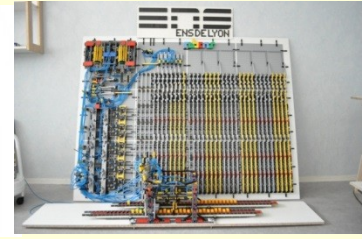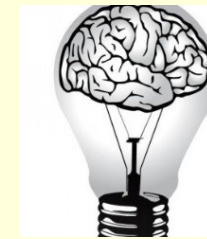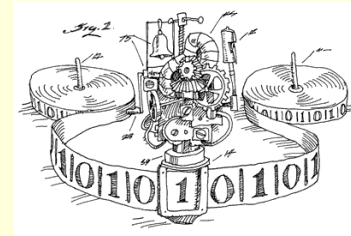(insert your "worst nightmare"   function here)

I WIN! I ALWAYS WIN!

Finding Busy Beavers

- Generate all machines of a given size
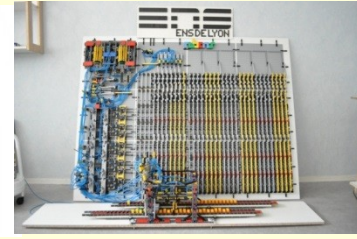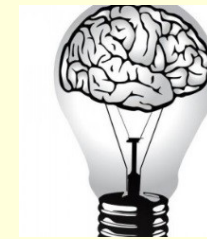- Remove those which do not terminate
- Take maximum of the rest

Assignment Project Exam Help

Problem 1: There a   hines with n states
(n= 5 gives 'only' 2   https://eduassistpro.github.io/ nes (!) ☺)

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Problem 2: How can we write a pr   lassify machines
into terminating and non-terminating?

No **general** method, but …

Monsters are rare …

prod	5	6	7	8	9	10	11	12	13
number	73,61					79	13	6	5	2

Assignment Project Exam Help

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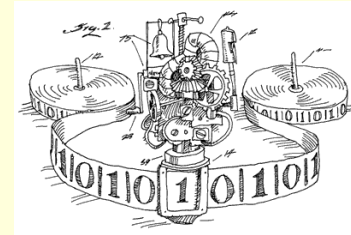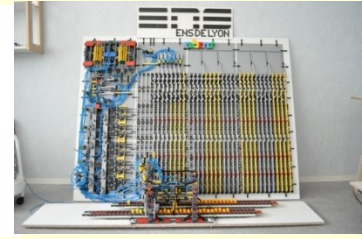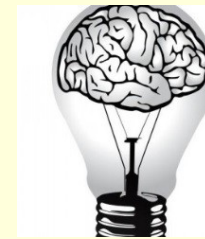
Of 117,440,512 4-state machi
- 89,207 irredundant and terminate with prod ≥ 5
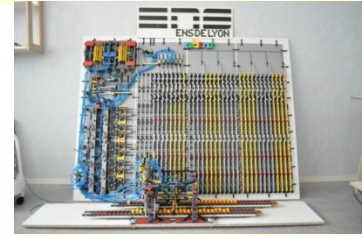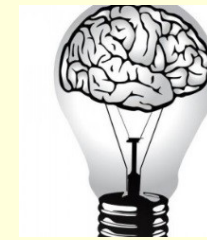- only 2,561 machines with prod > bb(3)
- loops abound!
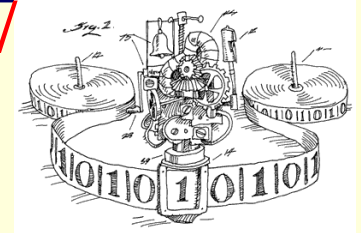
5-state monsters …

prod	max	transitions
4098	12,288	47,176,870
4098	6,144	11,798,826
4097		764
4097	6,143	6
4096	6,143	11,804,910
4096	6,143	11,804,896
1471	1,474	2,358,064

Platypus Machines

An n-state machine of productivity m shows
- bb(n) ≥ m
- at most n states are needed to print m 1's
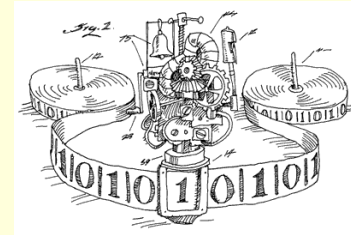
Question: what i   of states
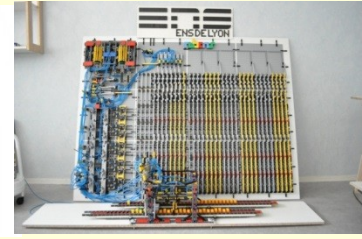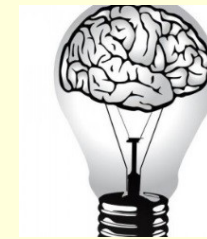needed to print

We call this the placid platypu

Known Platypus values

- 1-83 except 46, 48, 50, 74, 75, 77, 80, 82
- 87,88,89,91,99,112,...
- ...,1471, (...?...), 3098, 4097, 4098

Question: Is it true that there ... e machine which prints m 1's for each bb((5)?

This is certainly false for bb(5) to bb(6).
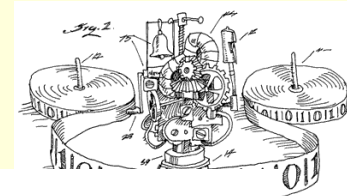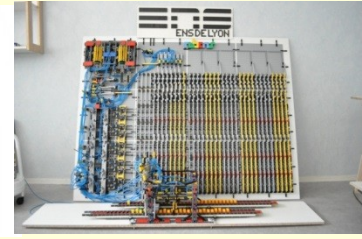
Platypus questions

- Distribution of platypus machines for n = 5
- Largest interval [m1,m2] of **existence?**
- Largest interval [m1,m2] of **non-existence?**
- Smallest m s.t.
- Distribution of
- Smallest m s.t.

n=6

Questions?

Questions?

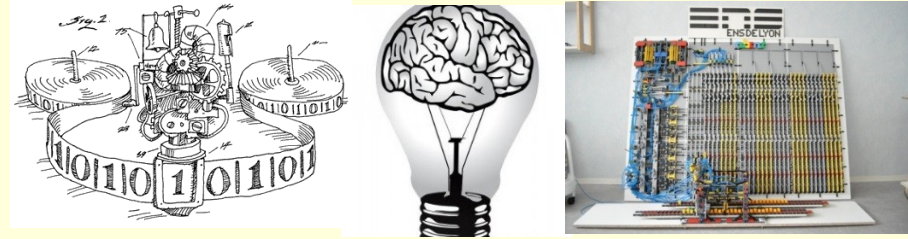Assignment Project Exam Help

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Questions?

Universal TMs

- Quest for the smallest universal TM goes on …
- Involves searching similar (but larger) spaces

Alain Colmerauer (KR'08 talk)
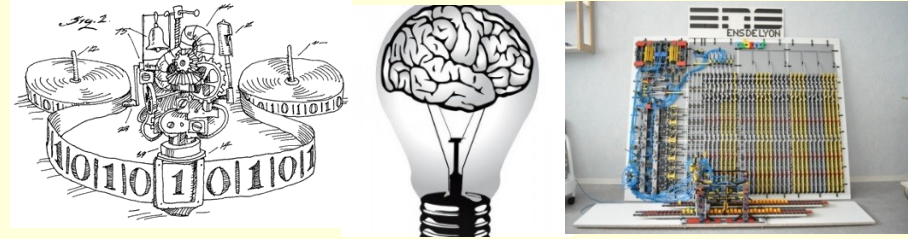- U on code(M)c   w
- Let M = U
- U on code(U)co

- Let w = blank (and assume co   blank)
- U on code(U) simulates U on blank

Hence pseudo-universality test: M is pseudo-universal if M on code(M) simulates M on blank

Universal TMs

- What exactly is the definition of a universal Turing machine?

- How can such definitions be used to identify universal machines "in the wild"?

- What constrain ing function?

- Does a UTM have to terminat
- Must a UTM terminate on code(M)code(w) exactly when M terminates on w?

- What is an appropriate "architecture" for a UTM? (code(M)code(w) vs code(w)code(M))

Questions?

Questions?

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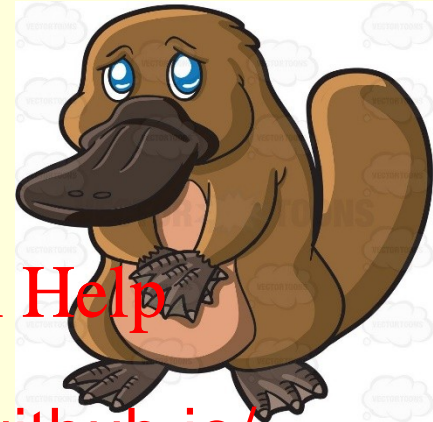
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Questions?

The Platypus Game

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The Platypus Game

This is a research project!

- You have done a lot of initial experimentation
- Rules and scoring much improved
- Still need to find champion machines
- 2-animal and 3-animal cases?
- Eliminate unfai
- Exercise in Tur
- Exercise in deal

- More work to be done!

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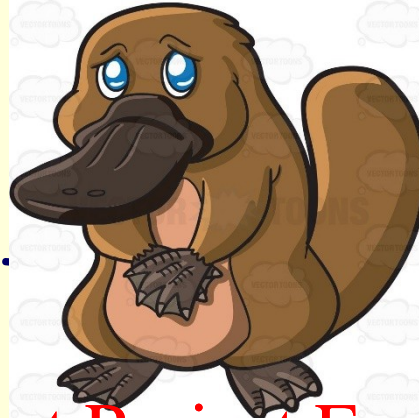
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Computing Theory

That's it!

...am ou...

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Computing Theory

That's it!

I am out of here!

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The lecture ~~Add WeChat edu_assist_pro~~ ed.

Break time! (We resume when all the pictures are gone! This will take 3 minutes!)

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