

Exploring COMPUTER SCIENCE

Prof. Hamzeh Roumani,
3M National Teaching Fellow
Dept of Computer Science and Engineering, York University

Exploring CSE

1. How is CS unique?
2. What is Science?
3. Is computer science a Science?
4. Building the CS Universe
5. Areas of Study
6. Concluding Remarks
7. Questions

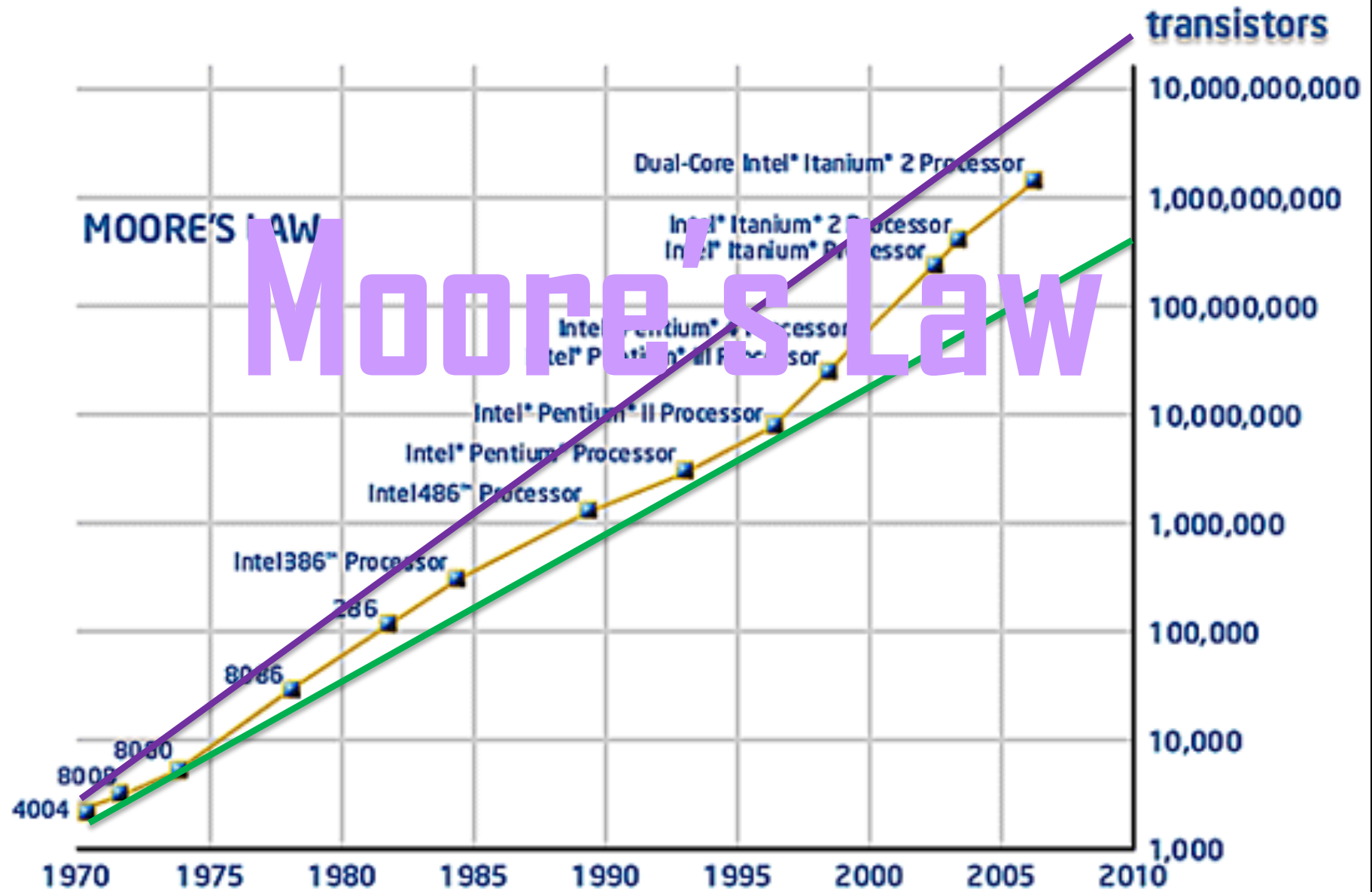
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How is Computer Science Unique?

Pace
of Progress

Pervasiveness
into "everything"



Source: www.intel.com

PERVASIVENESS

Telecom, Manufacturing, Banking, ...

IP-Based Intellectual Property

Enables ~ \$5T = 10% World GDP

Infrastructure of the **economy**

Consumer-centred services

Web 2.0 Societies

Physics, Biology, ... even **Math**

Is CSE a “Life Changer”?

What innovations have changed the way life is lived and business is done in the past 30 years?

http://www.pbs.org/nbr/site/features/special/top-30-innovations_home/

<http://knowledge.wharton.upenn.edu/article.cfm?articleid=2163>

The New York Times (Mar 7, 2009) and PBS Business Report (Feb 16, 09)
Judges from the Wharton School, University of Pennsylvania.

1. Internet
2. PC/laptop computers
3. Mobile phones
4. E-mail
5. Human genome mapping
6. MRI
7. Microprocessors
8. Fiber optics
9. Office software
10. Non-invasive surgery
11. Open source software
12. Light emitting diodes
13. Liquid crystal display
14. GPS systems
15. E-Commerce
16. Media file compression
17. Microfinance
18. Photovoltaic solar energy
19. Large scale wind turbines
20. Social networking
21. Graphic user interface
22. Digital photography
23. RFID
24. Genetically modified food
25. Bio fuels
26. Bar codes and scanners
27. ATMs
28. Stents
29. SRAM flash memory
30. Anti retroviral treatment

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What?

How?

The Spectrum of Sciences

Length Scale

Astronomy: parsec = 10^{16} m

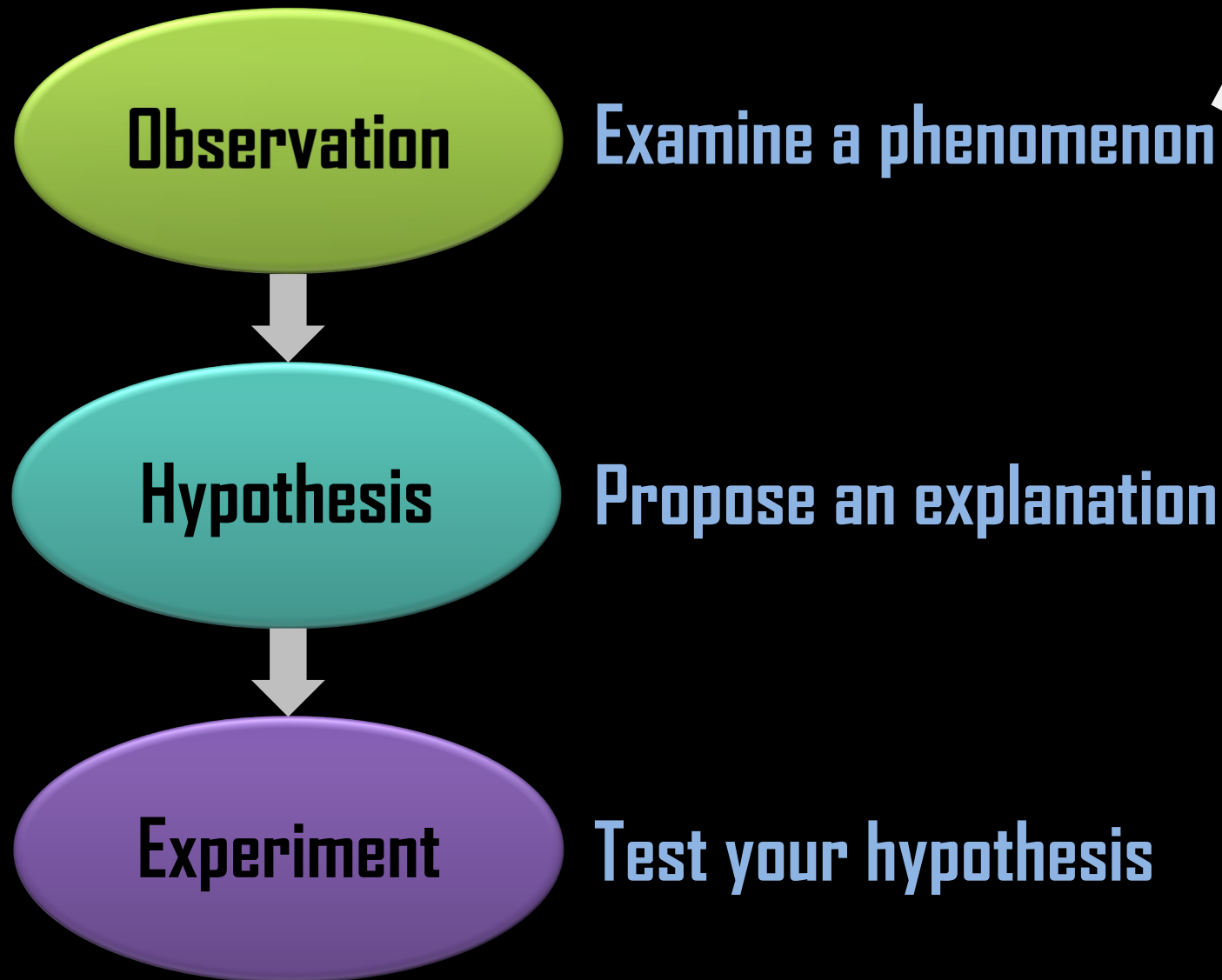
Geosciences: 1 km = 10^3 m

Biology: 1 micron = 10^{-6} m

Chemistry: 1 nanometer = 10^{-9} m

Physics: 1 fermi = 10^{-15} m

The Scientific Method



WHAT

HOW

The Evolution of Knowledge



Having established one hypothesis, find another that explains it at a deeper level.

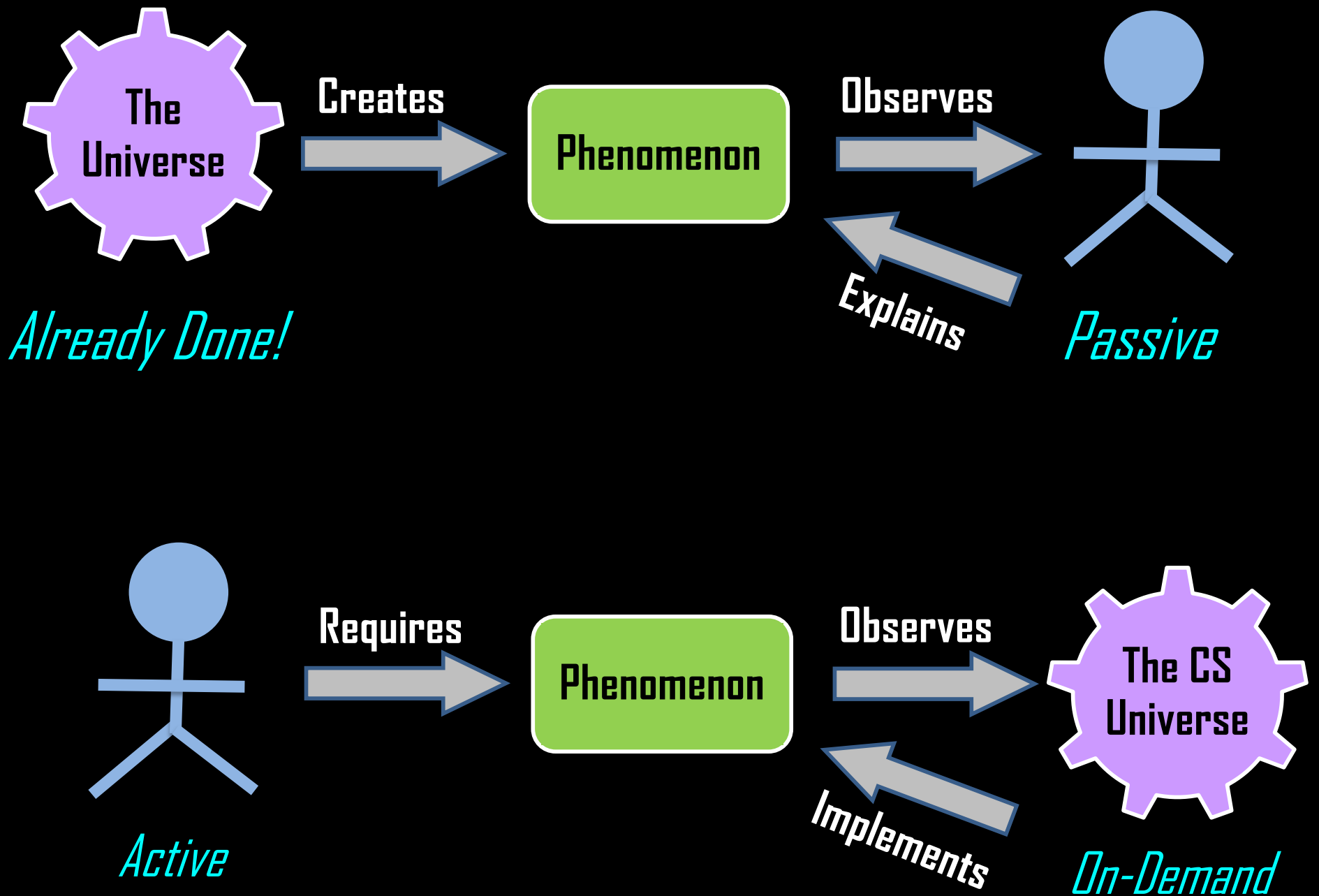


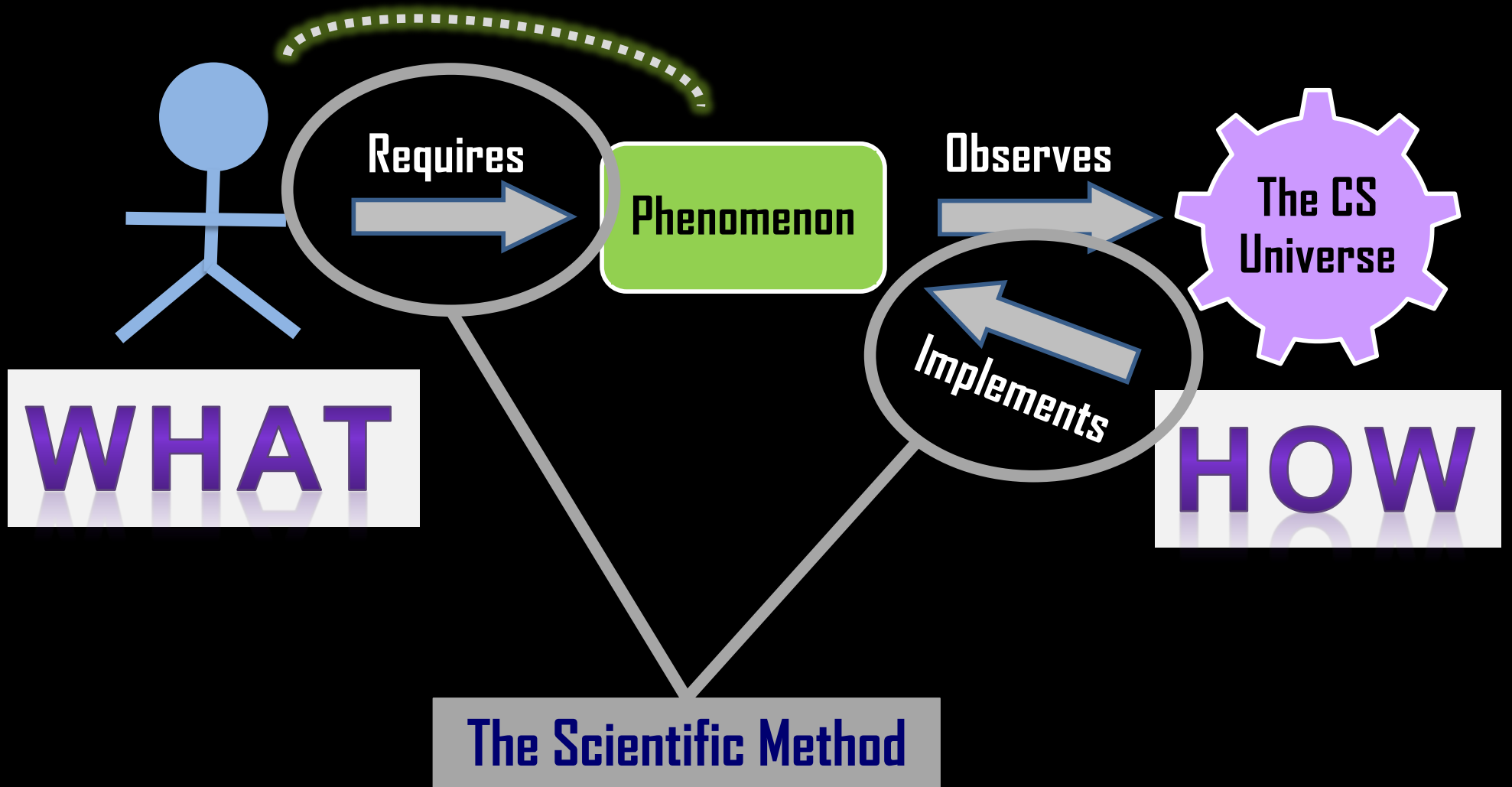
Having established several hypotheses, find one that incorporates all of them.

Hypotheses → Theories → Laws of Nature

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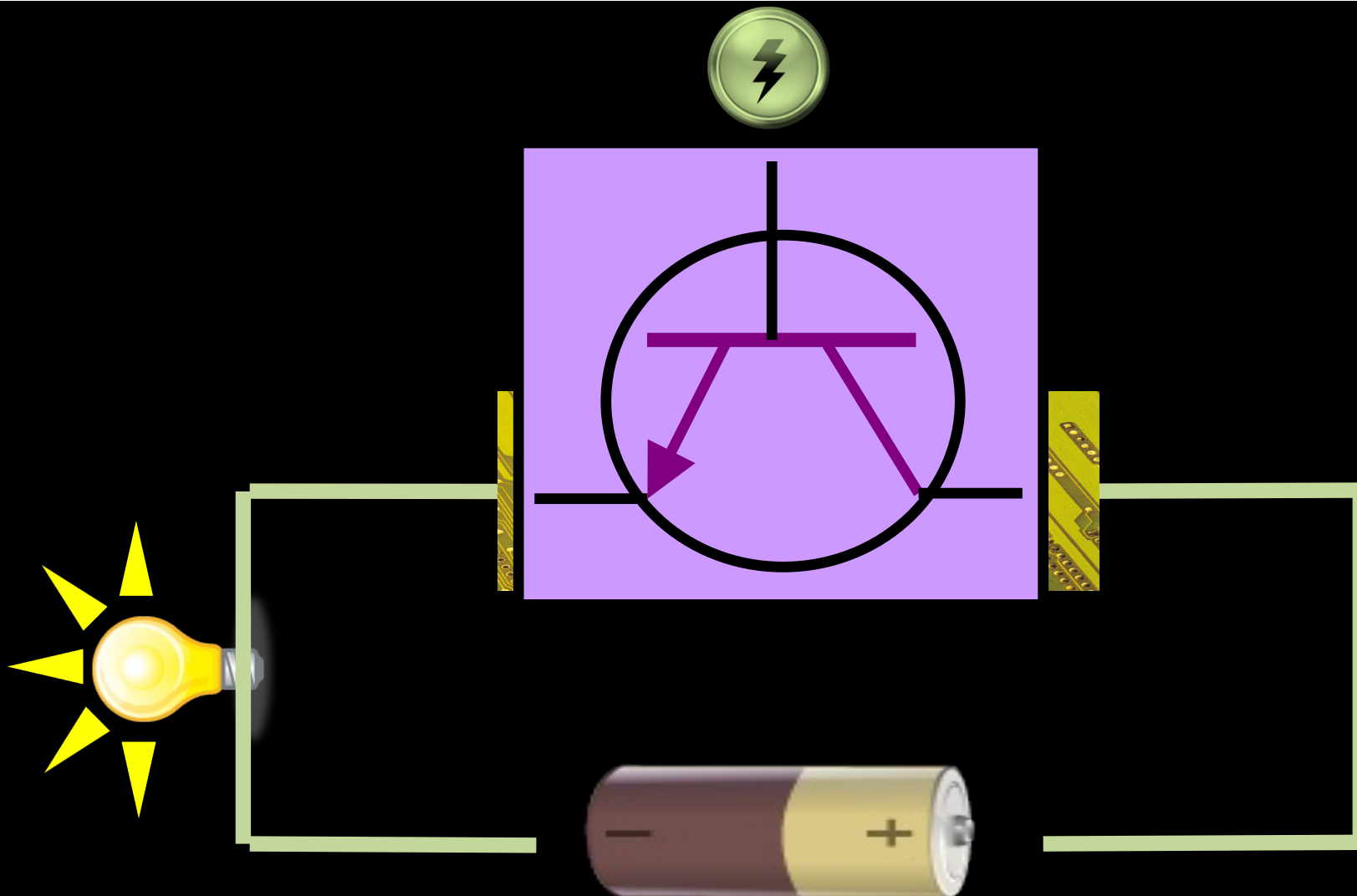


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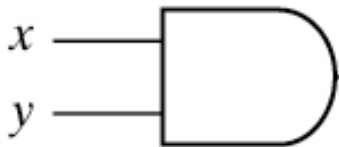

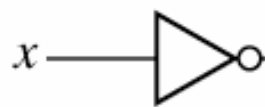


SEMICONDUCTORS



TRANSISTOR SWITCHES

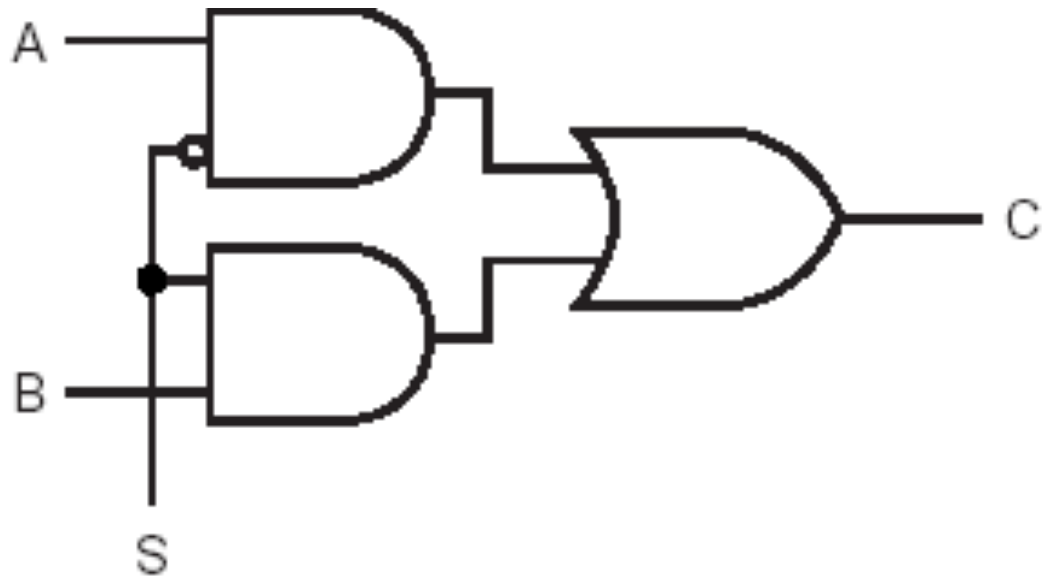
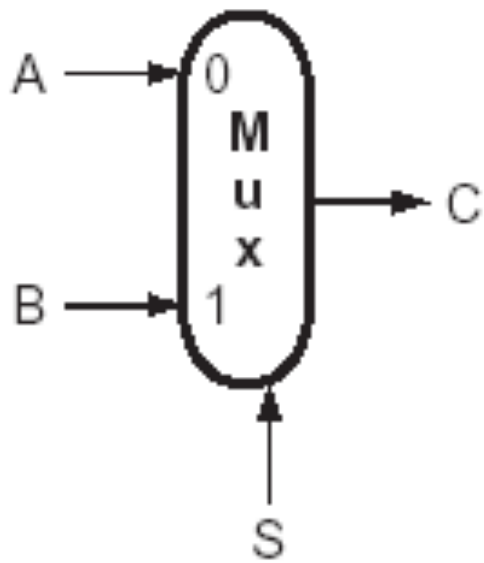
SEMICONDUCTORS

AND	 $F = xy$	<table border="1"> <thead> <tr> <th>x</th> <th>y</th> <th>F</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table>	x	y	F	0	0	0	0	1	0	1	0	0	1	1	1
x	y	F															
0	0	0															
0	1	0															
1	0	0															
1	1	1															
OR	 $F = x + y$	<table border="1"> <thead> <tr> <th>x</th> <th>y</th> <th>F</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table>	x	y	F	0	0	0	0	1	1	1	0	1	1	1	1
x	y	F															
0	0	0															
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1	1	1															
Inverter	 $F = x'$	<table border="1"> <thead> <tr> <th>x</th> <th>F</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> </tr> </tbody> </table>	x	F	0	1	1	0									
x	F																
0	1																
1	0																

and | or | not | xor | nand | nor GATES

TRANSISTOR SWITCHES

SEMICONDUCTORS



Select between two alternatives A and B

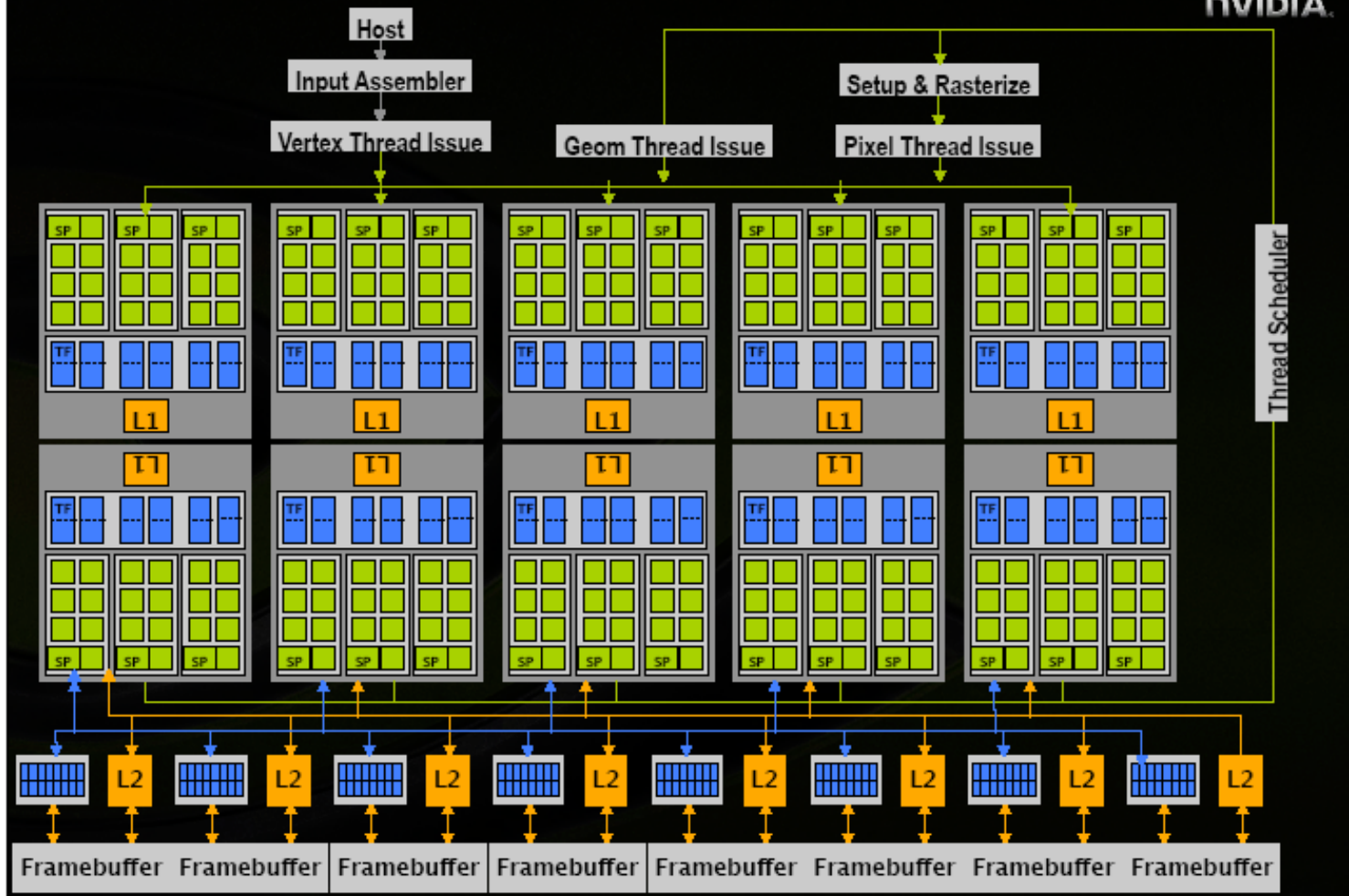
Combinational | Sequential

and | or | not | xor | nand | nor GATES

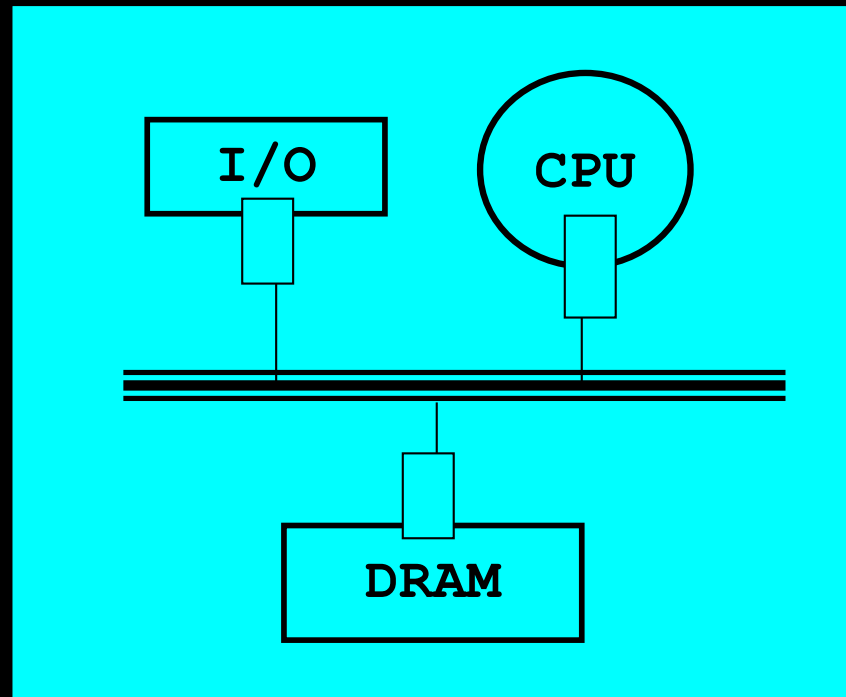
TRANSISTOR SWITCHES

SEMICONDUCTORS

Modern GPU Architecture: 240 Cores



SEMICONDUCTORS



ARCHITECTURE

DATAPATH | CONTROL

Combinational | Sequential

and | or | not | xor | nand | nor GATES

TRANSISTOR SWITCHES

SEMICONDUCTORS

WHAT without HOW

Vision | Robo | AI | HCI | CE | DB | Sim | Bio | DC | QC

Systems Design | Information Theory

POP objects | SOA services

High Level Programs

Low Level Code

O/S

ISA

DATA PATH | CONTROL

FUNCTIONS

RS

```
la    $a0, yes
addi  $s0, $0, 550
add   $t0, $0, $0
add   $t1, $0, $0
lbl:  lw   $t2, list($t1)
      beq  $t2, $s0, ok
      addi $t1, $t1, 4
      slti $t2, $t1, 40
      bne  $t2,
la    $a0, no
ok:   addi $v0,
      syscall
      jr   $ra
      round = (target == list[i]);
}
```

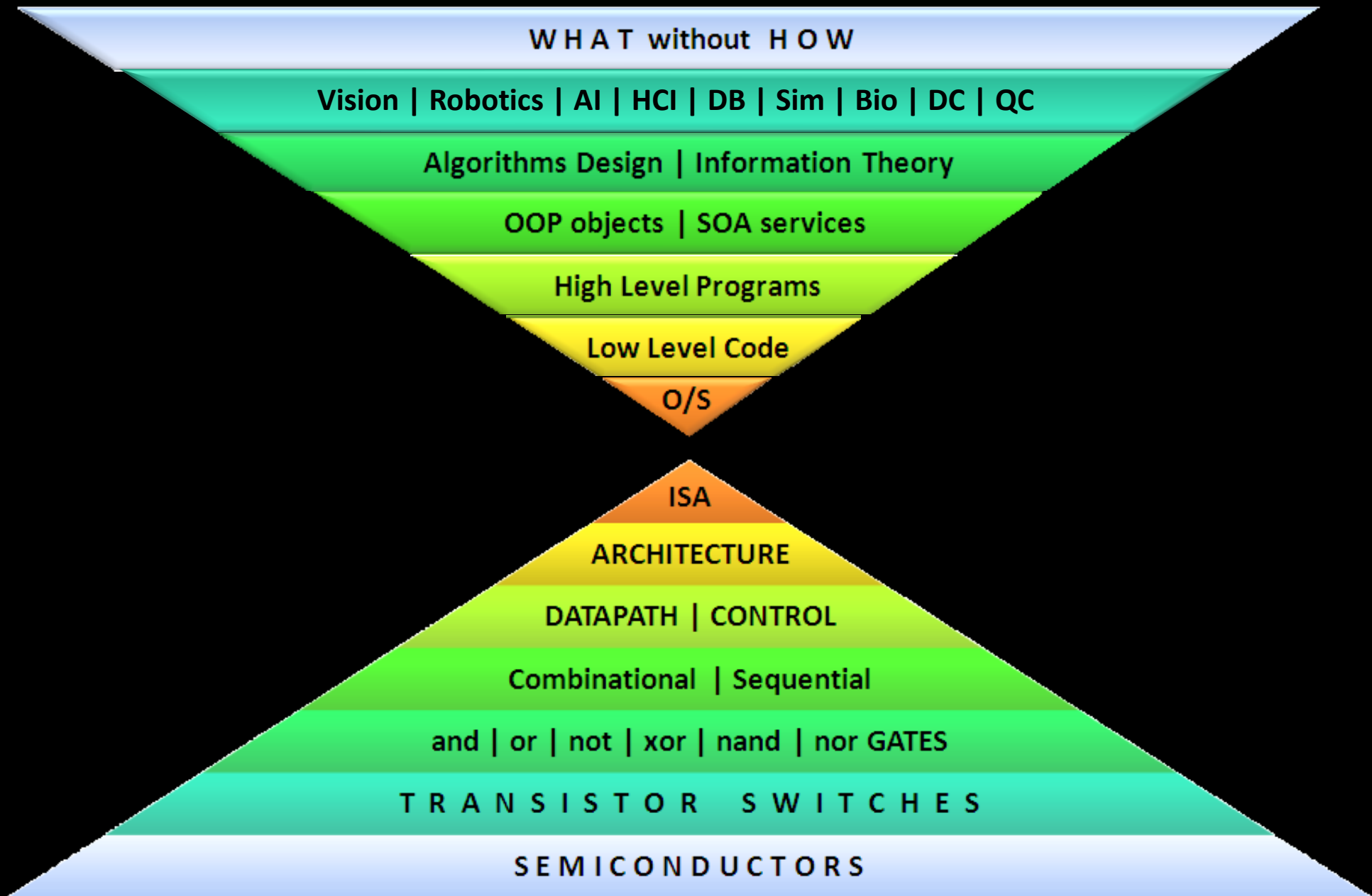
```
boolean found = list.contains(target);
```

```
Select * from list where key = target;
```

```
boolean found = service.invoke(target);
```

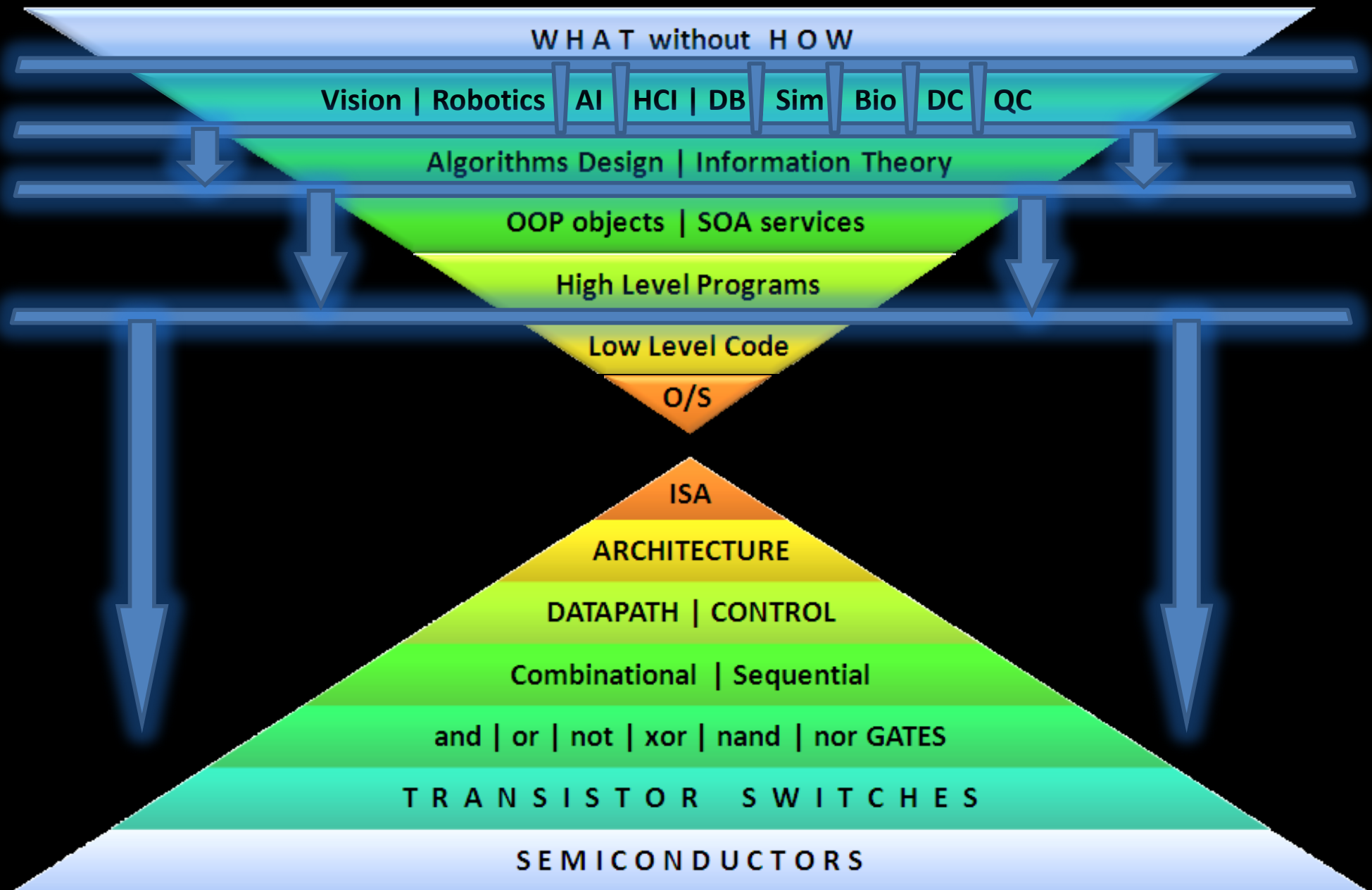
```
0x3c011001
0x34240028
0x20100226
0x00004020
0x00004820
0x3c011001
0x00290821
0x8c2a0000
000006
0x21290004
a0028
0x1540fffa
11001
0x54240031
0x20020004
0x0000000c
0x03e00008
```

The Computing Universe



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General Areas

1. Hardware and Systems

2. Software and Applications

3. Theory

4. Computing Methodologies

AI and Machine Learning, Graphics, Vision,
Robotics, HCI, Information Networks, ...

Hardware and Systems

1. Virtualization → the Cloud
2. RFID, Nanotechnology, ...
3. Sensor Networks
4. Reconfigurable Computing
5. DNA Computing

Software and Applications

TIME FLIES LIKE AN ARROW

Verb Verb Verb

Software and Applications



Users



Developers

Requirement

Specification



Analysts

Software and Applications



Users



Developers

Requirement

Architect

Specification

Business Analyst

System Analyst

Data Analyst

Database Specialist

Network Specialist

Security Specialist



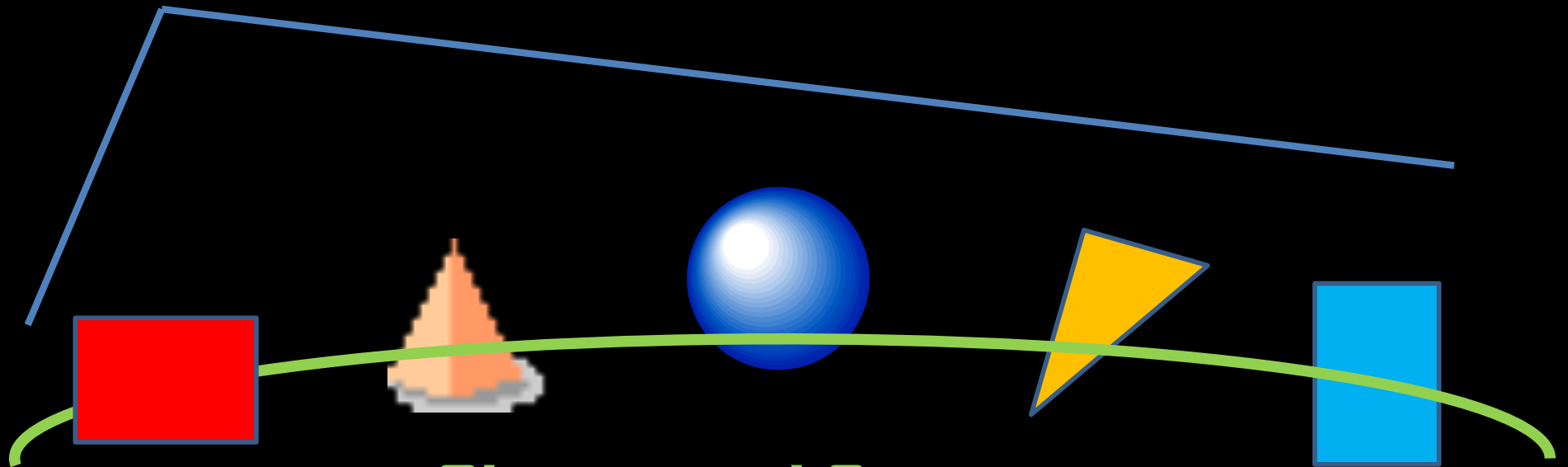
Analysts

Software and Applications



Developers

- XML Technologies
- Assembly of Components
- Automatic Code Generation



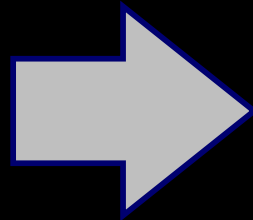
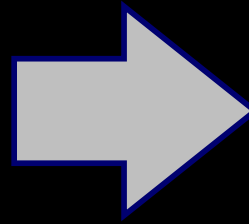
Objects and Services

Theory

1. What is Computable?
2. How Quickly can we Compute?
3. Algorithms, Serial and Parallel
4. Cryptography

...

HCI: Human-Computer Interaction



Source: wikipedia.org

Vision and Robotics

- Human and Machine Vision
- Visual Processes
- Motor and Cognitive Processes
- Visually-Guided Robotics
- Related Clinical Diagnosis and Treatment



Centre for Vision Research
<http://www.cvr.yorku.ca>

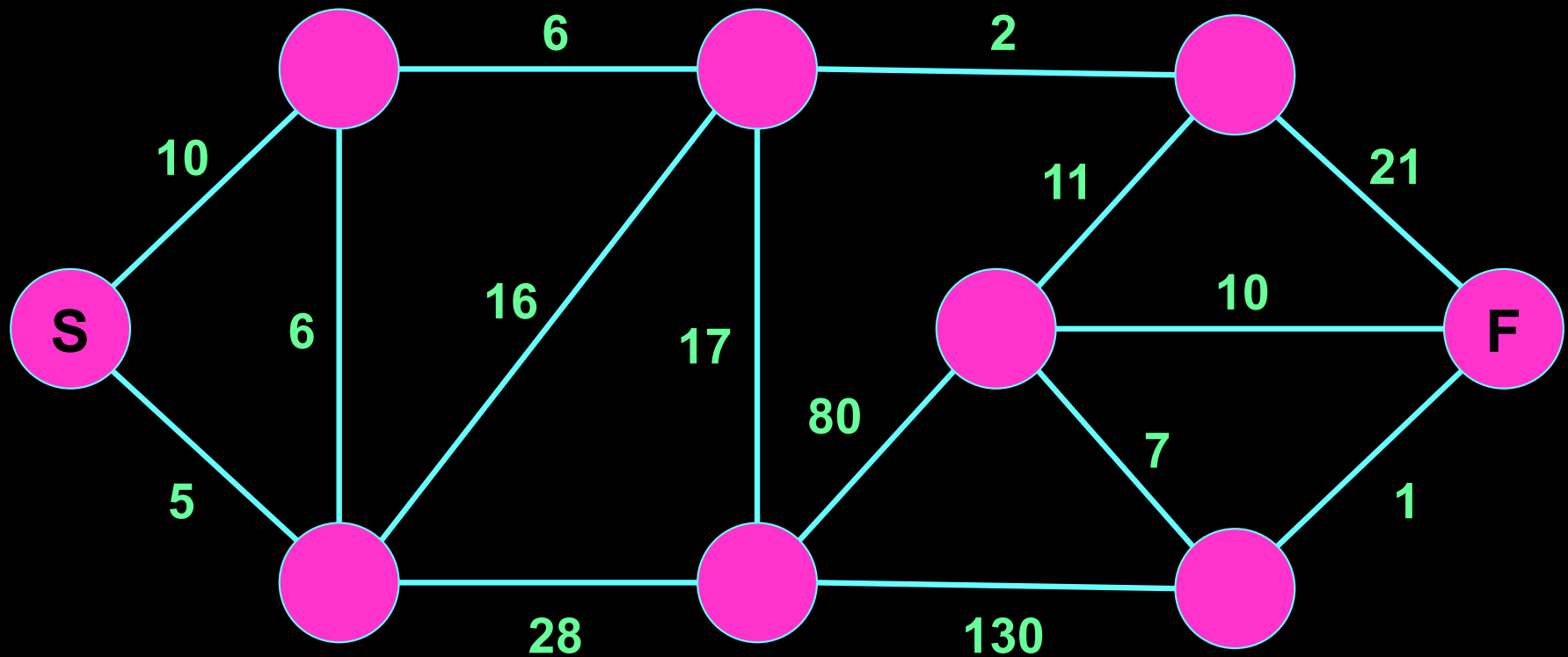


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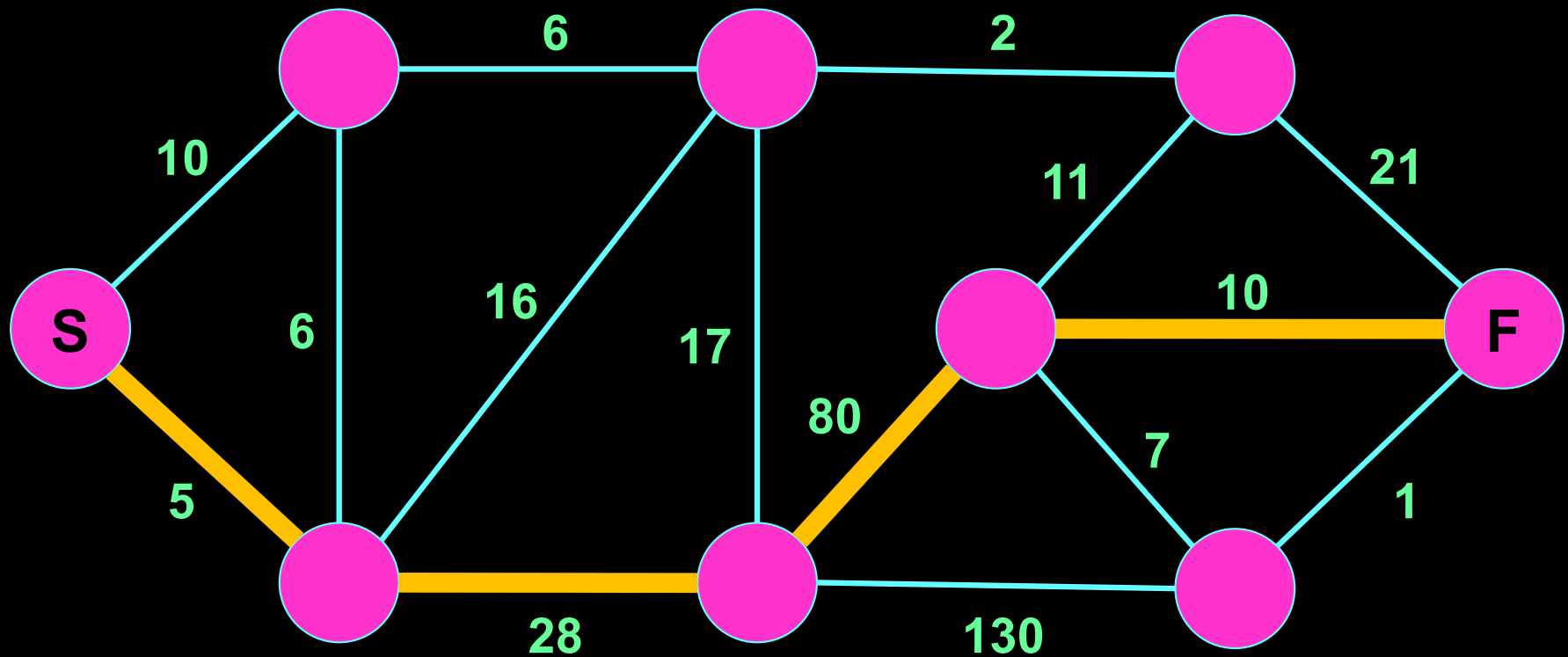
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EXAMPLES

What is the shortest path from S to F?

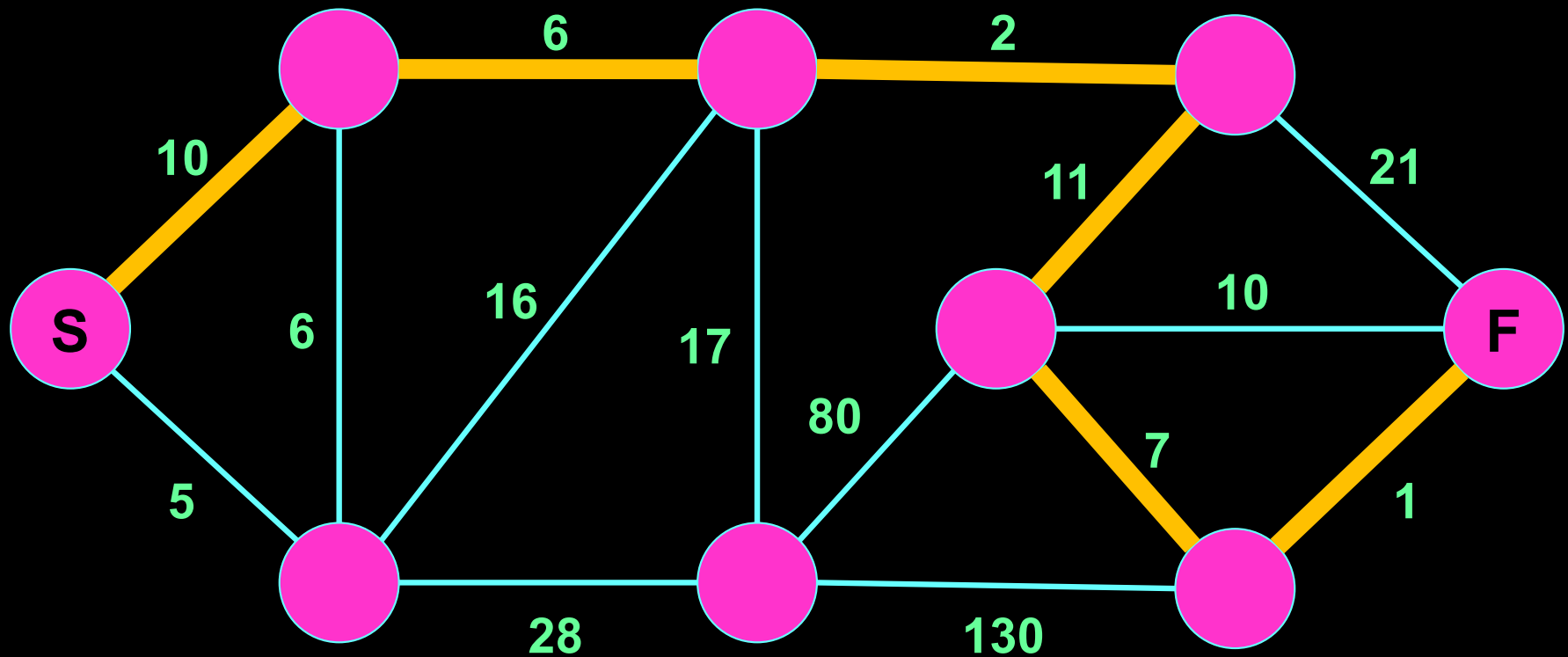


Is this Optimal?



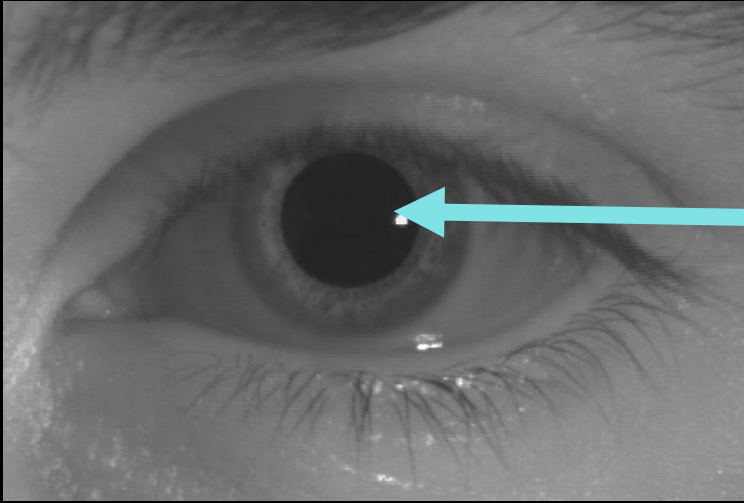
$$5 + 28 + 80 + 10 = 123$$

The Optimal Path:



$$10 + 6 + 2 + 11 + 7 + 1 = 37$$

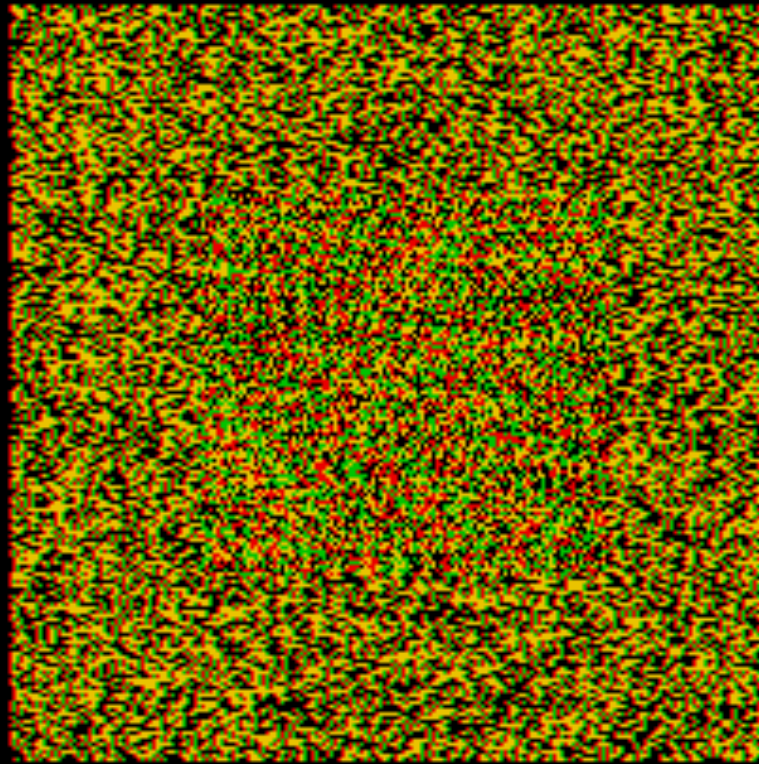
Vision



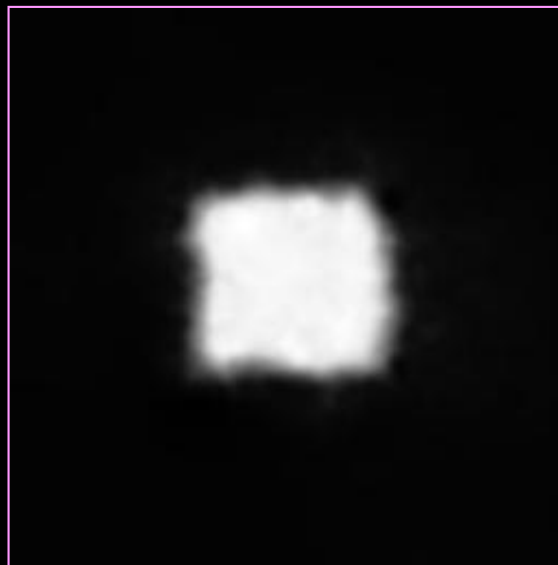
128	123	123	131	124	68	68	70
122	124	138	139	89	72	68	70
121	126	135	136	75	69	69	69
125	127	130	131	80	79	75	70
125	126	255	132	75	78	75	75
126	125	130	80	75	72	75	74
125	126	127	80	79	77	76	75
126	127	127	79	78	78	77	76

Source: Prof. Richard Wildes, York University

Vision – Stereopsis



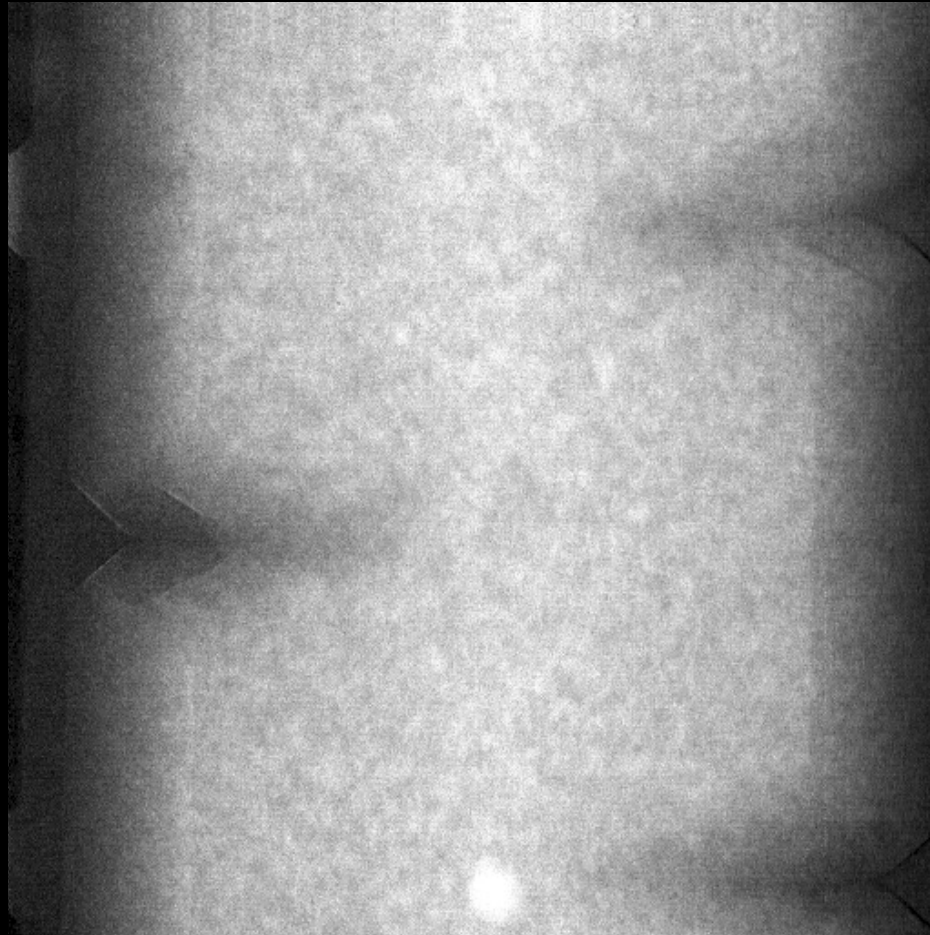
Source: Prof. Richard Wildes, York University



Depth Map

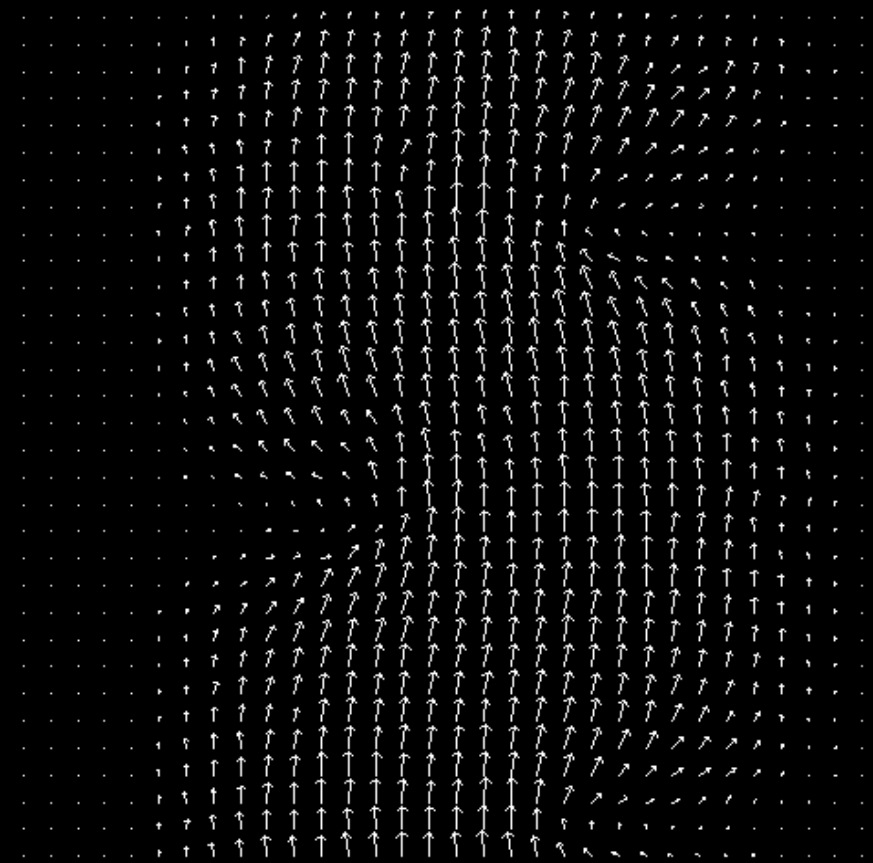
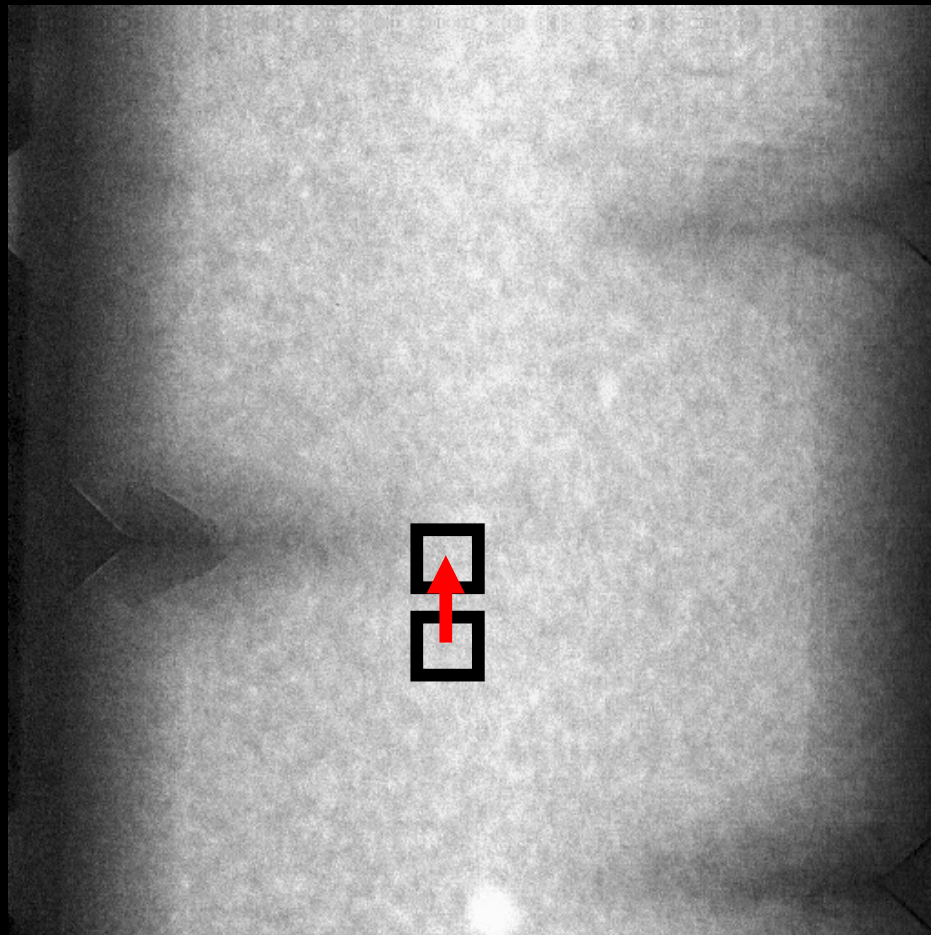
Source: Prof. Richard Wildes, York University

Vision – Motion Analysis



Source: Prof. Richard Wildes, York University

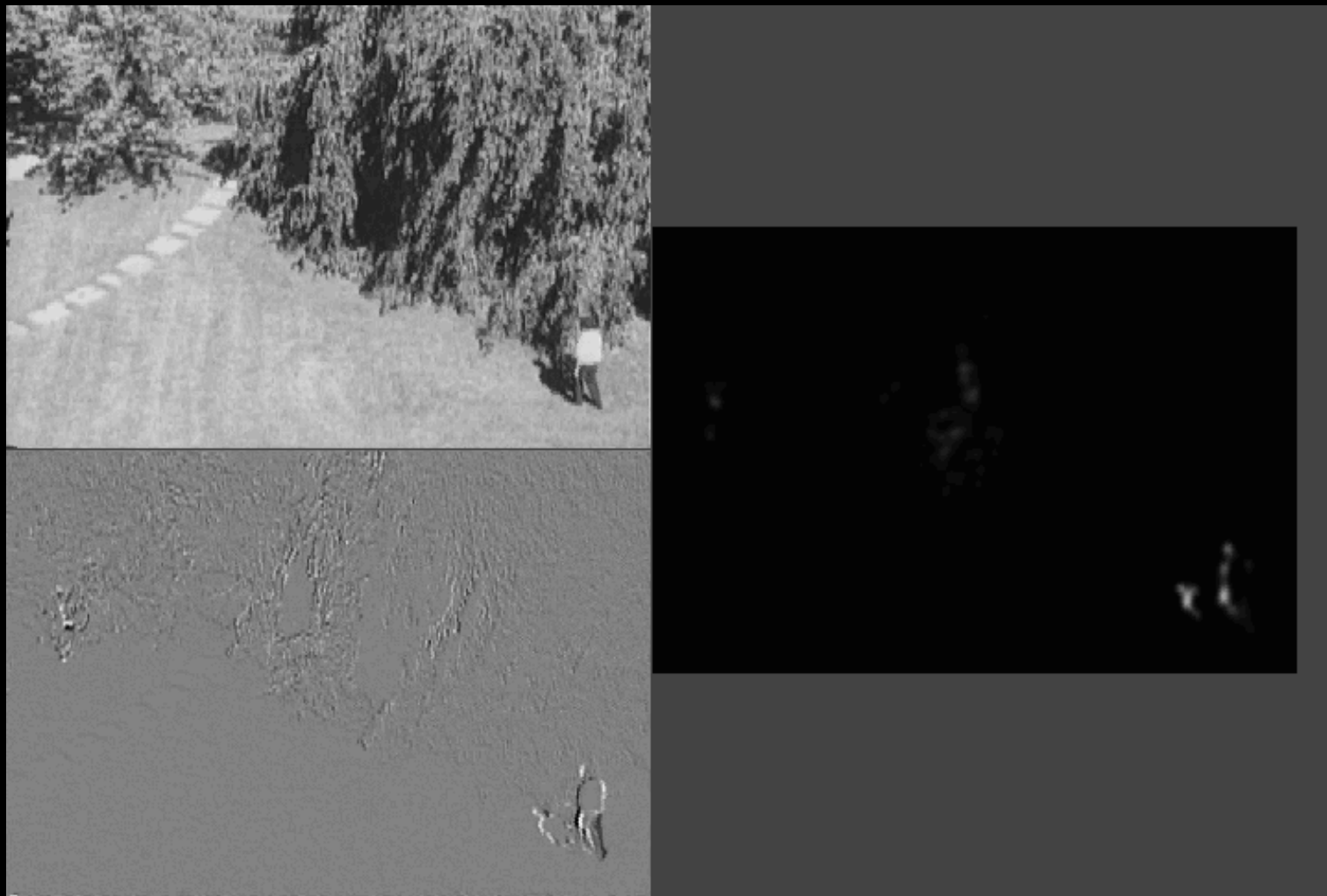
Vision – Motion Analysis



Velocity Field

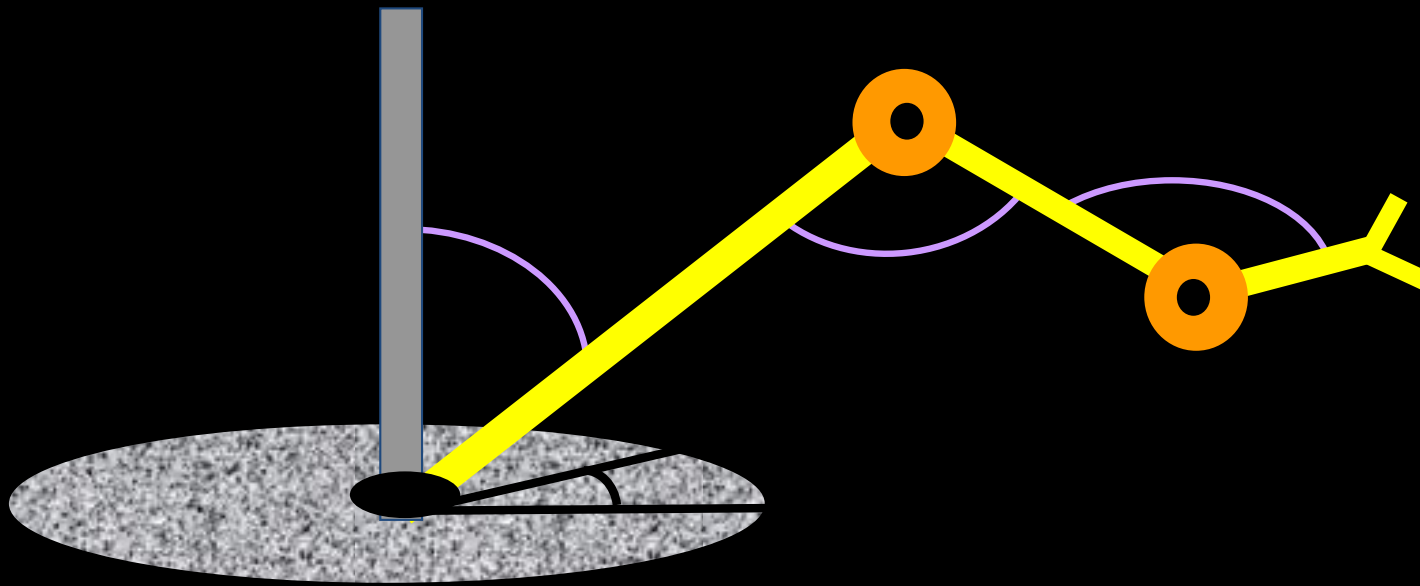
Source: Prof. Richard Wildes, York University

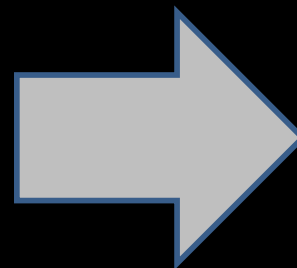
Vision – Motion Analysis



Source: Prof. Richard Wildes, York University

Controlling a Robotic Arm





One Button!

-	T	I	H	F	B
E	O	R	C	P	Z
A	S	U	G	Q	DEL
N	D	Y	J	,	0
L	W	X	.	1	2
M	K	?	3	4	5
V	'	6	7	8	9

Source: M. Baljko et al, ASSETS'06

	T	I	H	F	B
E	U	R	C	P	Z
A	S	U	E	U	DEL
N	U	Y	J		U
L	W	X	.	1	2
M	K	?	S	4	5
V	.	6	7	8	9

E	O	R	C	P	Z
---	---	---	---	---	---

E	O	R	C	P	Z
---	---	---	---	---	---

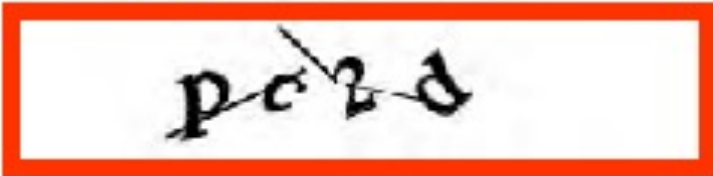
https://cd.t.yahoo.com/config/eval_register?intl=us&ncw=1&.don

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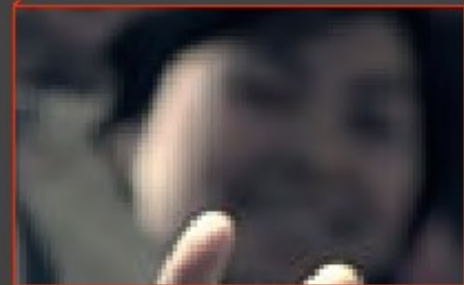
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Internet | Protected Mode: Off | 100%

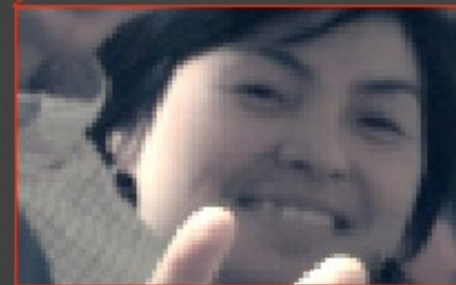
Focus in Software



conventional photograph,
main lens at $f / 4$



conventional photograph,
main lens at $f / 22$



light field, main lens at $f / 4$,
after all-focus algorithm
[Agarwala 2004]

Acknowledgments

- **Souad Al-Hakim,**
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For being an inspiration to managing complexity
- **Colleagues and Students,**
Faculty of Science and Engineering, York University
For sharing their knowledge, insights, and experiences