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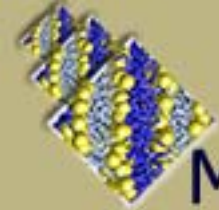
Content, Metadata & Flexible Reuse within the MatDL Transport Archive

Laura M. Bartolo¹, Javed I. Khan², Adam C. Powell IV³

¹ College of Arts & Sciences, Kent State University

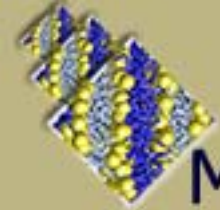
² Computer Science, Kent State University

³ Materials Science and Engineering, MIT

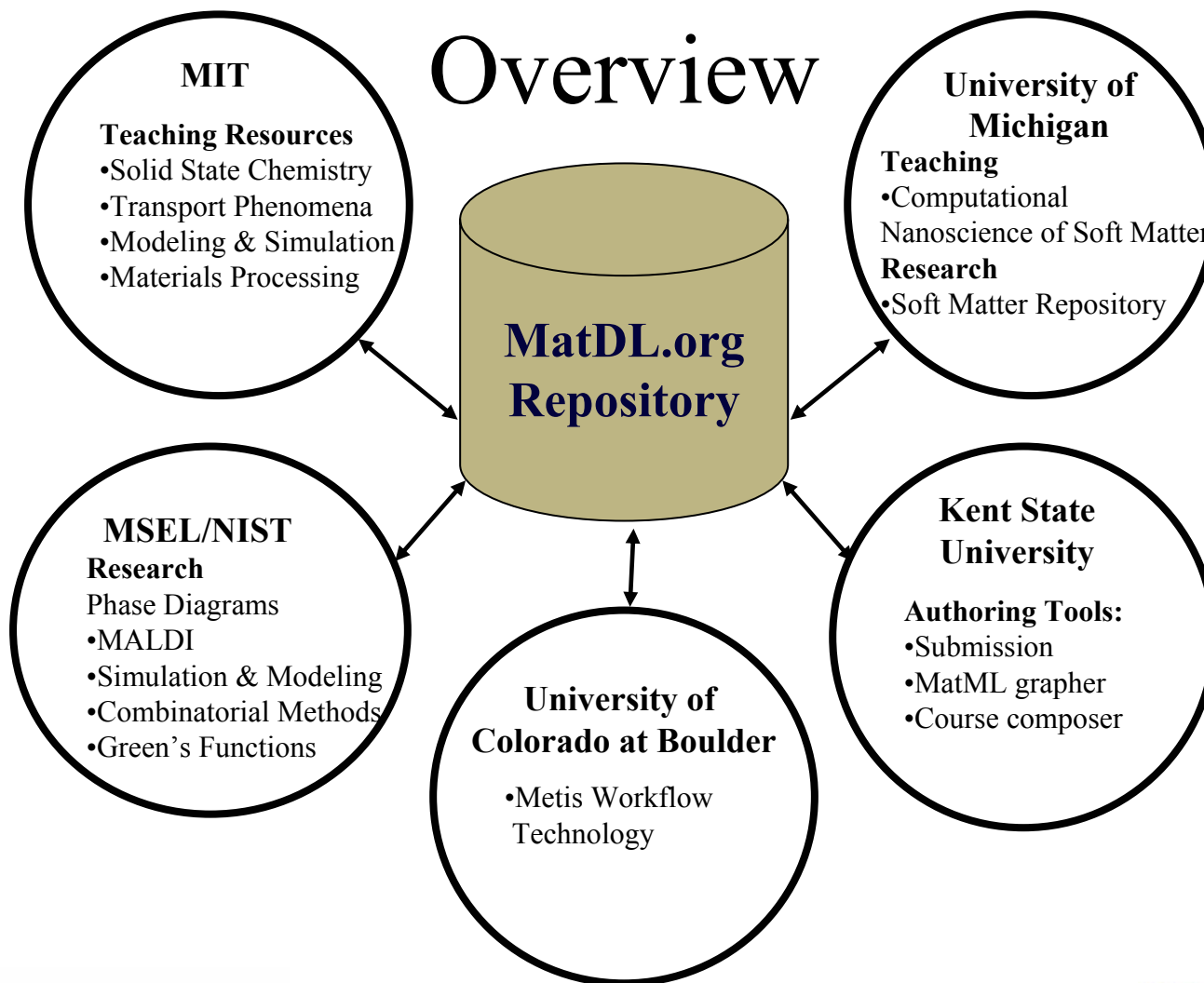


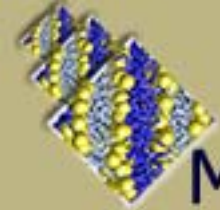
Outline

- Background
 - MatDL Overview
 - Transport archive
 - Metadata
 - Ontology
- Course Composer



Overview





Materials Digital Library

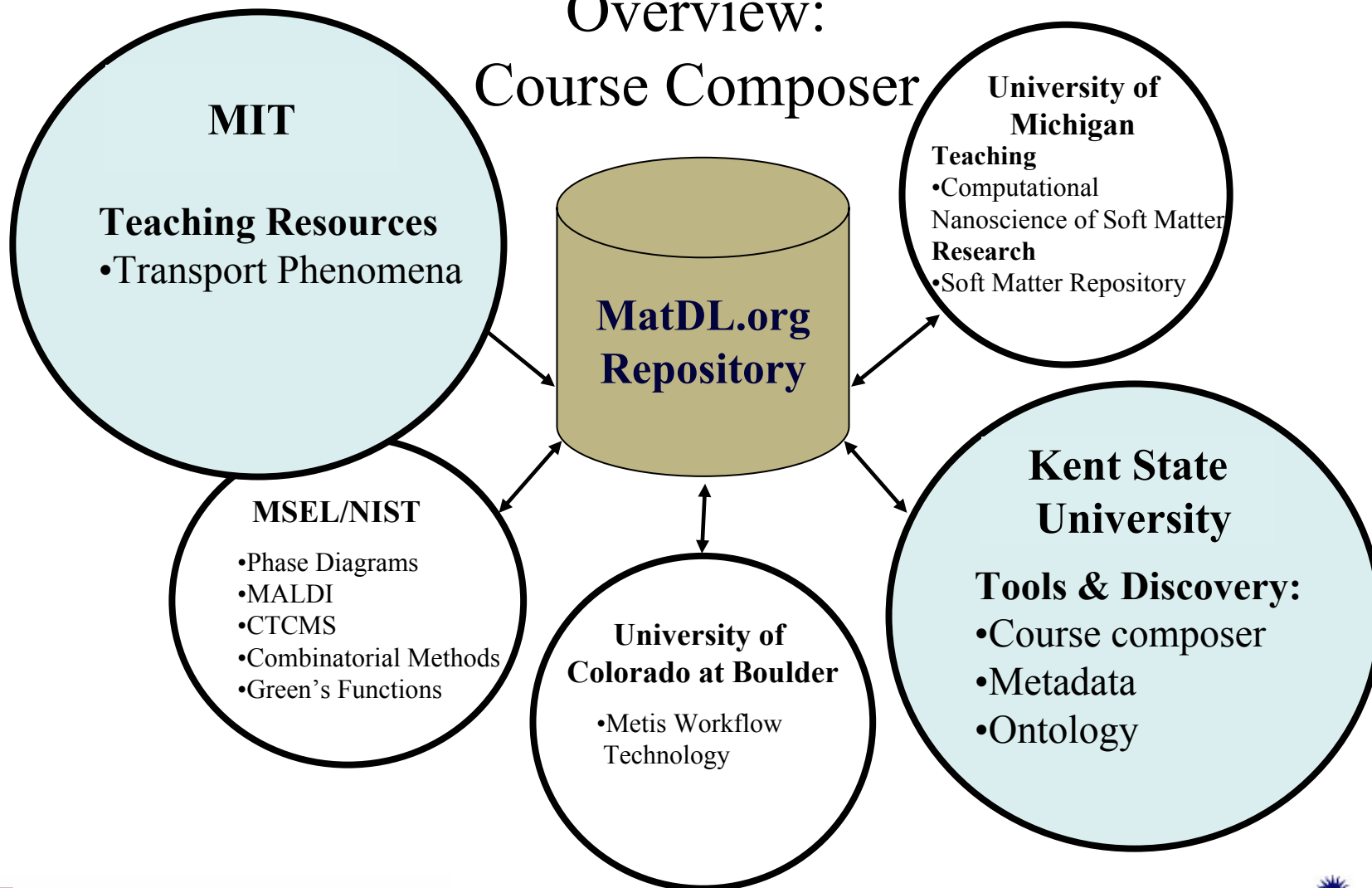


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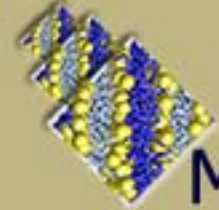
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Overview: Course Composer



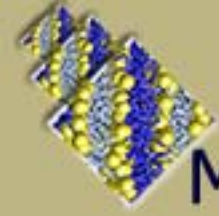
NSDL Annual Meeting 2004

12/13/2004



MatDL Transport Archive

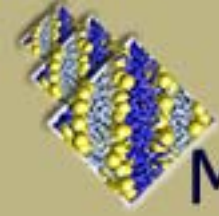
- Online space for collaborative development of transport educational resources
- Transport phenomena: fluid dynamics, heat and mass transfer
- Content: readings, lecture notes, handouts, exercises, courseware, pedagogical mat'ls
- Metadata: currently ad-hoc, later IEEE LOM
- Initial focus on materials processing cases
- Four contributors, sixteen users (USA, Canada, Mexico, Japan, Sweden)



Transport Archive Content

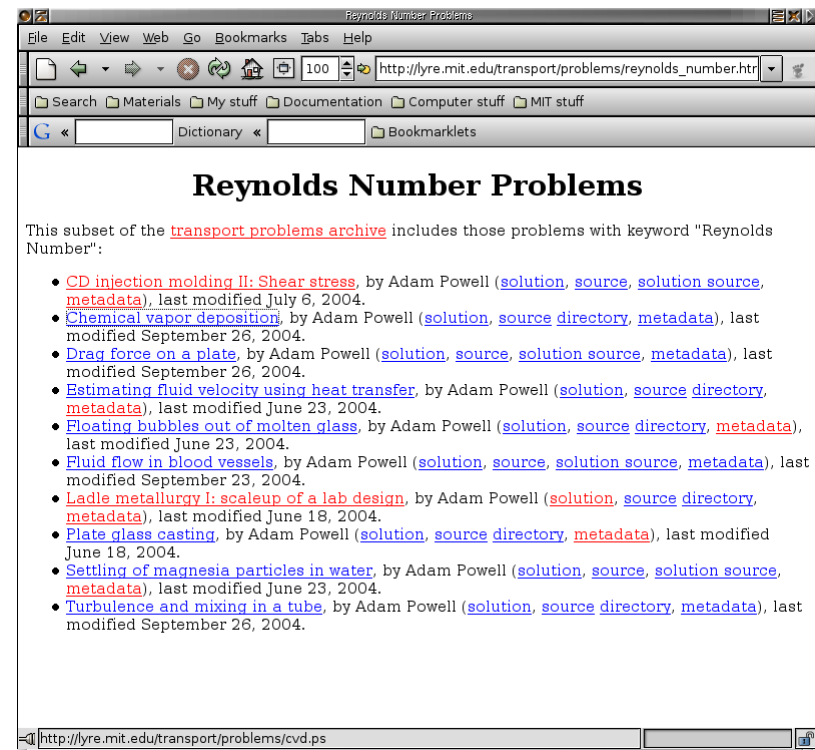
- Resource content:
 - Author, copyright
 - Brief description
 - Source (.tex, .doc)
 - Printable (.pdf, .ps)
 - Checksum(s)
 - Problems and solutions
 - Student level
 - Solution time
 - Key words

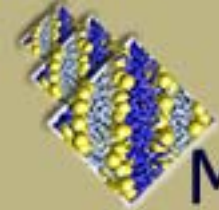
The screenshot shows a web browser window titled "Transport Problems Archive". The address bar contains the URL "http://lyre.mit.edu/transport/problems/". The page content includes a welcome message, a list of searchable metadata attributes, and a list of keywords. The metadata attributes listed are: Author name(s), copyright and license; Brief one-sentence description; Requisite software, if any; Problem and solution source format (e.g. MSWord, OpenOffice.org, (PDF)LaTeX); Problem and solution printable format (e.g. PDF, PostScript); Difficulty level (approx. undergraduate year or G); Approximate solution time, in hours; and Keywords. The keywords are organized into four columns: Diffusion, Phase change, Macroscopic balance, Heat conduction, Radiation, Solidification, Evaporation, Biot number, Fourier number; Dimensional analysis, Computation, Viscous flow, Stokes flow, Navier-Stokes, Reynolds number, Non-Newtonian fluid, Drag force, Bernoulli equation; Boundary layers, Forced convection, Natural convection, Heat/mass transfer coefficient, Prandtl/Schmidt number, Nusselt/Sherwood number, Grashof number, Continuous flow reactors; Metal, Polymer, Ceramic, Glass, Composite, Electronic materials, and Biomaterials. At the bottom, there is a link to view the list of problems in alphabetical or reverse chronological order.



Resource Listing

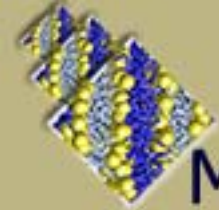
- Gives title, author, links to source etc.
- Problems include qualitative (sketch), quantitative (calc), design components
- Designed for easy modification, reuse





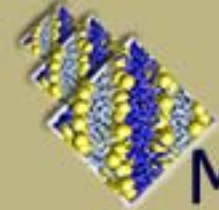
Transport Archive Impact

- Free high-quality resource for educators
- Forum to rapidly transfer research results in this area to educational use
- Quickly build a course, including ABET objectives/outcomes
- Timely launch: many materials departments cutting classes in processing/transport
- Online case studies help to compensate for this trend



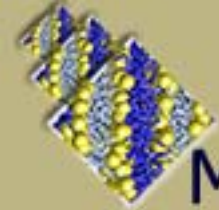
Transport Archive Future Plans

- Metadata format: ad hoc to standard compliant
- Advisory board, review process
- Migrate version control, workflow software to Fedora, Metis
- Content: mechanical, chemical engineering
- Content: structure formation
- Content: nanofabrication, manufacturing
- Resource links to transport ontology
- New courseware: property graphs and selection, flow past sphere, etc.



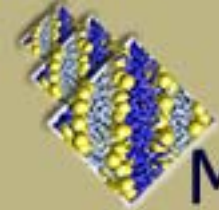
Metadata

- Dublin Core (DC)
 - Used by MatDL repository (DSpace)
 - Fields stored in database
- Learning Object Metadata (LOM)
 - Used by Course Composer
 - XML files



LOM Metadata: Educational

- `<interactivityType>`
 - `<value>active</value>`
- `<learningResourceType>`
 - `<value>exercise</value>`
- `<context>`
 - `<value>higher education</value>`
- `<typicalLearningTime>`
 - `<duration>PT1H30M</duration>`



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Transport Resource Viewed in MatDL

Materials Digital Library

Search DSpace: [DSpace at MatDL.org](#) >
[Materials Transport Archive](#) >
[MIT 3.185, "Transport Phenomena in Materials Engineering"](#) >

Advanced Search

Home

Browse

- Keywords
- Titles
- Authors
- By Date

Please use this identifier to cite or link to this item: <http://hdl.handle.net/1862/1475>

Title: Thermal properties and optimal materials selection
Authors: Powell, Adam C. IV
Keywords: Heat conduction
Metal
Ceramic
Electronic materials
Issue Date: 2002
Publisher: MIT Open CourseWare
Citation: Powell, Adam C. IV (2002) Assignments - Problem Set 4. MIT Open CourseWare. <http://ocw.mit.edu/OcwWeb/Materials-Science-and-Engineering/3-185Transport-Phenomena-in-Materials-EngineeringFall2002/Assignments/index.htm>
Description: Choose the best materials from a list of candidates for six different applications based on thermal properties of those materials.
URI: <http://hdl.handle.net/1862/1475>

In Collections: [MIT 3.185, "Transport Phenom](#)

Problem/Exercise

1. Thermal properties and optimal materials selection

In many situations, product designs include parts whose only function is to conduct or resist the conduction of heat. Materials for these parts are thus chosen entirely on the basis of their thermal properties. Select the best material from the list provided for each of the following applications.

- Heat shield sandwiched between a hot body and a cold one which minimizes the steady flux between them.
- Heat shield which protects something from short, intense bursts of heat (long timescale is needed).
- Cheap (i.e. not diamond) temperature sensor, in which short timescale of heat conduction is necessary for rapid response.
- Light heat reservoir which must hold as much heat as possible per degree C per unit weight.
- Heat sink for a semiconductor device, which must minimize temperature difference for a given flux.
- Heat sink for melt spinning, in which liquid metal is injected against a rotating heat sink where it is solidified as rapidly as possible, so the material must conduct heat away from the surface quickly. (Hint: evaluate the flux through $x = 0$ in an erf-like unsteady conduction problem. Diamond is not an economically viable option.)

Candidate materials:

Material	$k, \frac{W}{m \cdot K}$	$\rho, \frac{g}{cm^3}$	$C_p, \frac{J}{kg \cdot K}$
aluminum	238	2.7	917
copper	397	8.96	386
gold	315.5	19.3	130
silver	425	10.5	234
diamond	2320	3.5	519
graphite	63	2.25	711
lime (CaO)	15.5	3.32	749
silica (SiO ₂)	1.5	2.32	687
alumina (Al ₂ O ₃)	39	3.96	804

Files in This Item:

File	Description
thermselect.pdf	printable p
thermselect.tex	problem so
thermselect-solution.pdf	printable s
thermselect-solution.tex	solution so
trnsprt_thermselect_prob_sol.xml	

LOM Metadata

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  <catalog>URI</catalog>
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    <string>Choose the best materials from a list of candidates for six different applications based on thermal properties of those materials.</string>
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    <string>Heat conduction</string>
    <string>Metal</string>
    <string>Ceramic</string>
    <string>Electronic materials</string>
  </keyword>

```

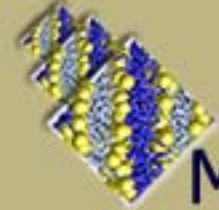


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NSDL Annual Meeting 2004

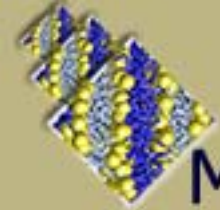
12/13/2004



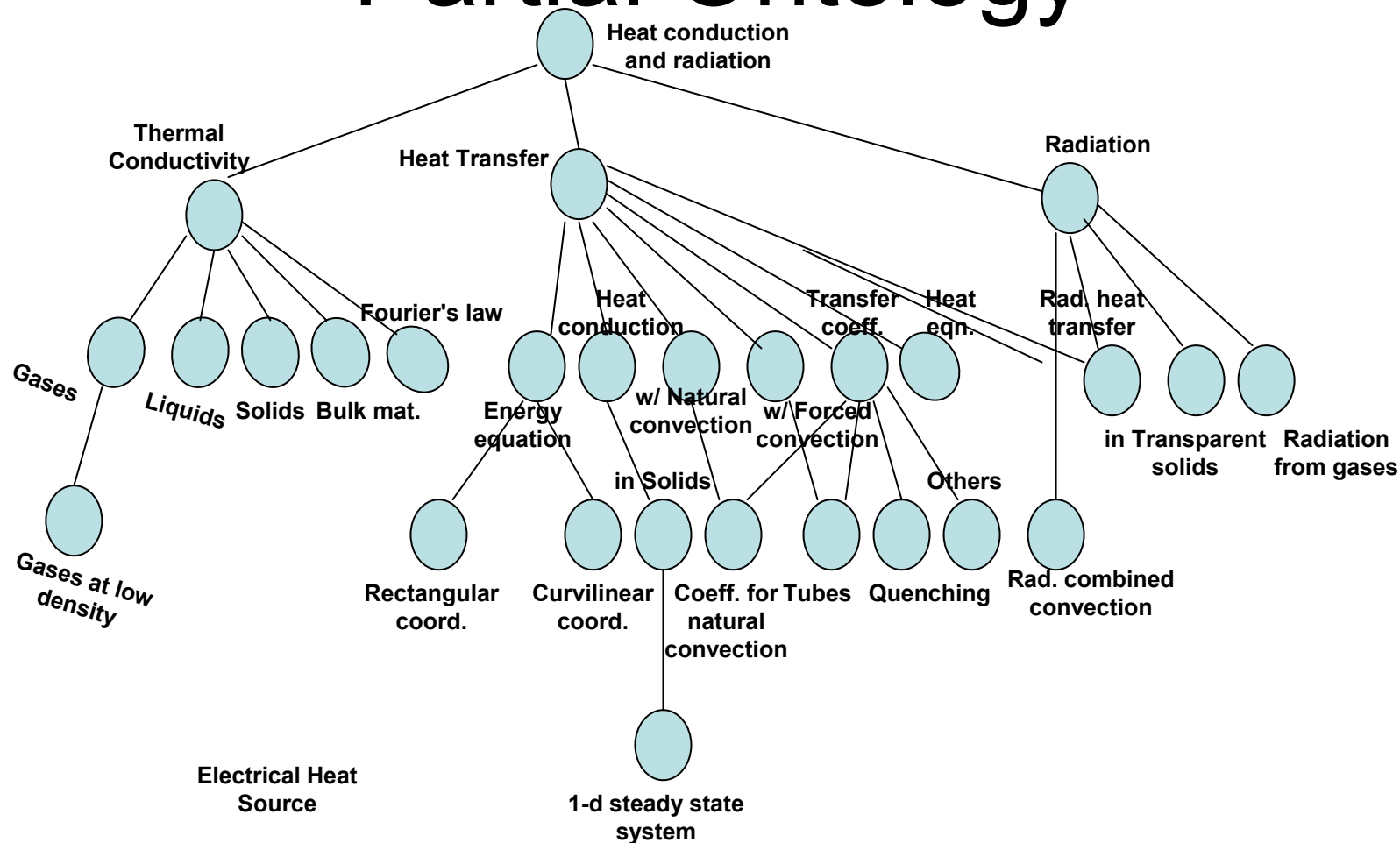


Transport Phenomena Ontology

- MSE perspective
- Developed from:
 - Course syllabus
 - Textbook

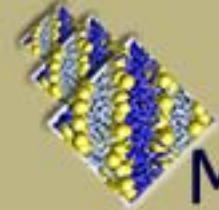


Partial Ontology



Electrical Heat Source

1-d steady state system



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The authors would like to acknowledge the support of National Science Foundation grant DUE-0333520 and National Institute of Standards and Technology grant 70NANB3H1079.

Thank you!

Questions?

Course Composer

Course Composer

- A framework under which teaching materials can be creatively shared by a community.
- Currently there are substantial amount of “digital elements” made available in electronic format and some in course web-site in ad-hoc manner by self-motivated volunteers.
- But the goal of “reusability” seems to be still illusive!
- The course composer is a metaphor targeted to create a framework which attempts to push the depth to which course materials can be contributed, searched, repurposed for creative, customized and automated composition.

Main Features

- Human composer (user) can specify a thematic outline of the course and expect the system (Course Composer) to complete the conceptual design.
- A user can expect the Composer to find deeply targeted and intelligently related course materials.
- A user can expect the Composer to help in automatically creating high level composed objects such as lecture plan, lecture notes, handout, even exams!

Sample Capabilities

Sample Capability-1

- **Question:** I would want to know more about “Thermal Diffusion”. Would you find some reading material?
- **Course Composer:** Yes. But to know about “Thermal Diffusion” also one needs to know about “Flick’s law” and “Phase Transformation”. How much time would you like to spend on them??

Sample Capability-2

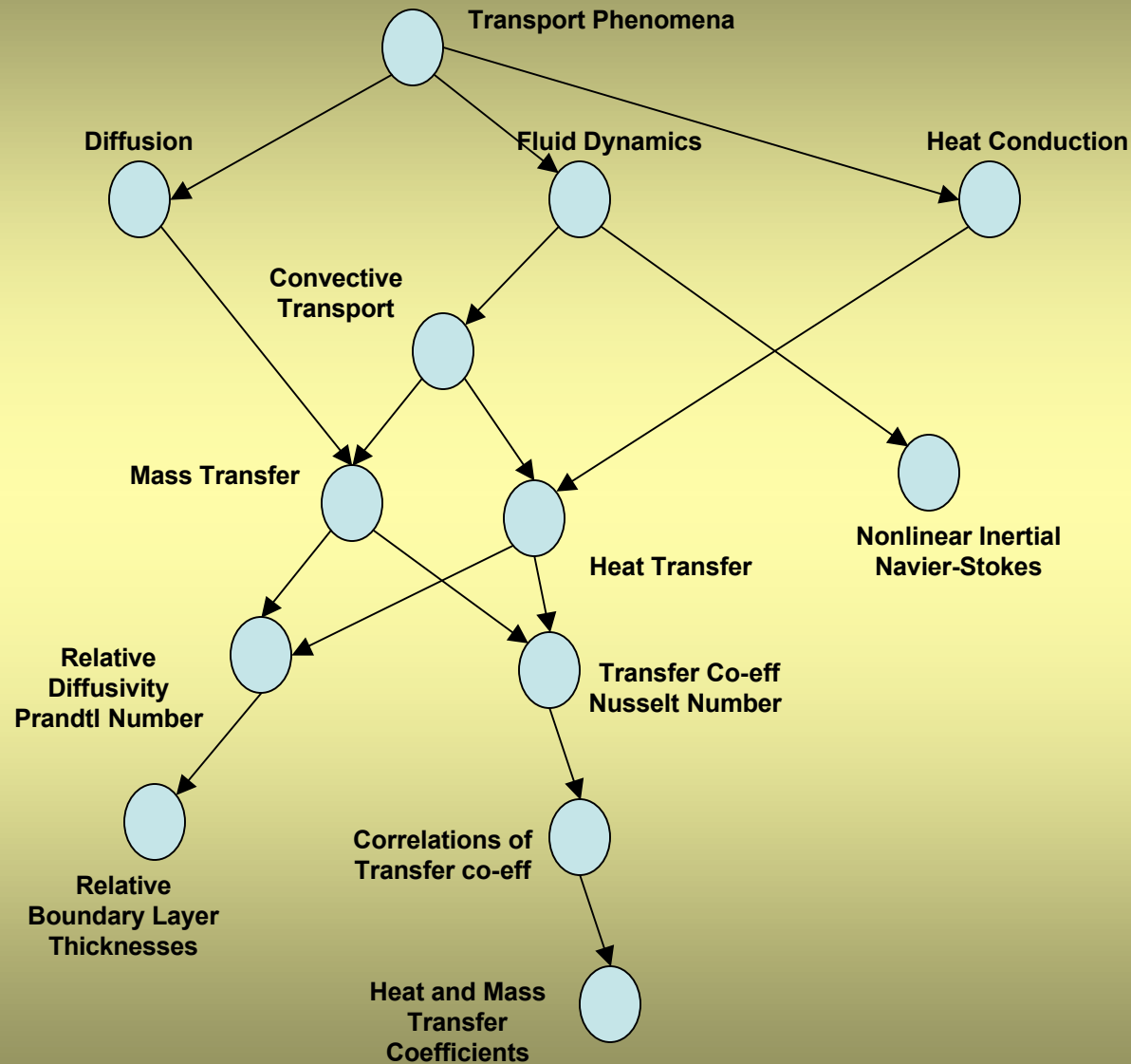
- **Question:** Help me creating a “Quiz” on thermal conductivity. Can you find some questions?
- **Course Composer:** How hard you want them to be?
- **Question:** I think about one or two should be of simple complexity but one must be quite hard.
- **Course Composer:** OK! I have found three questions- one multiple choice- testing the area of “gases at low density”, one narrative type question testing the area “liquid”, and another mathematical type testing the area of “solid” area. The last one is quite hard as it would require knowledge about all four prerequisite areas. I think roughly it will take 25 minutes to answer them.

Sample Capability-3

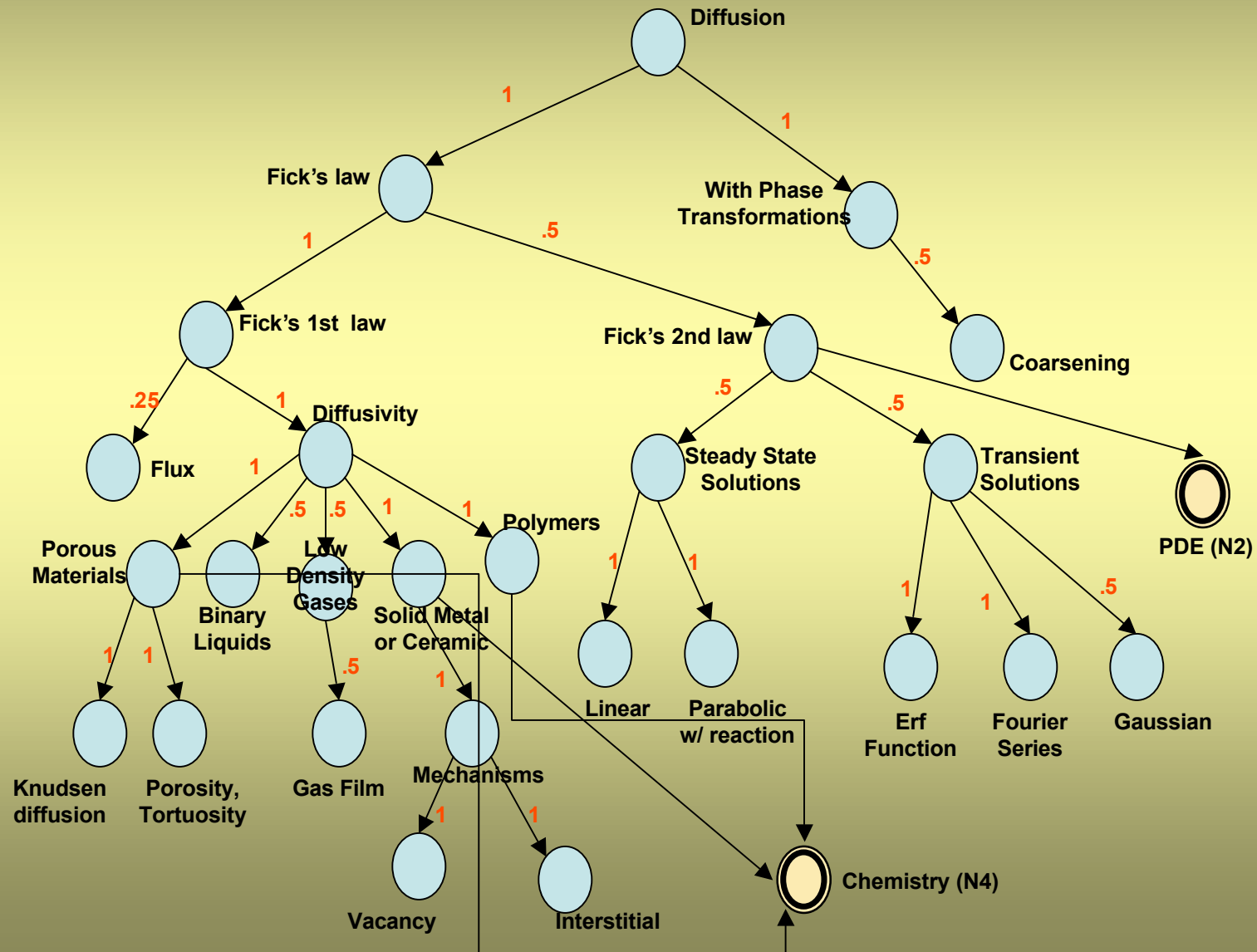
- **Question:** I would like to know what topics I should cover for a new transport phenomena course I am developing specially for Biology majors. What preparatory topics to be added to current topics?
- **Course Composer:** I would suggest that you add a review discussion on “partial differential Equation” and “numerical solution approaches”. Also I suggest that you include discussion on “vascular wall” and “blood biochemistry”.

Composition Process

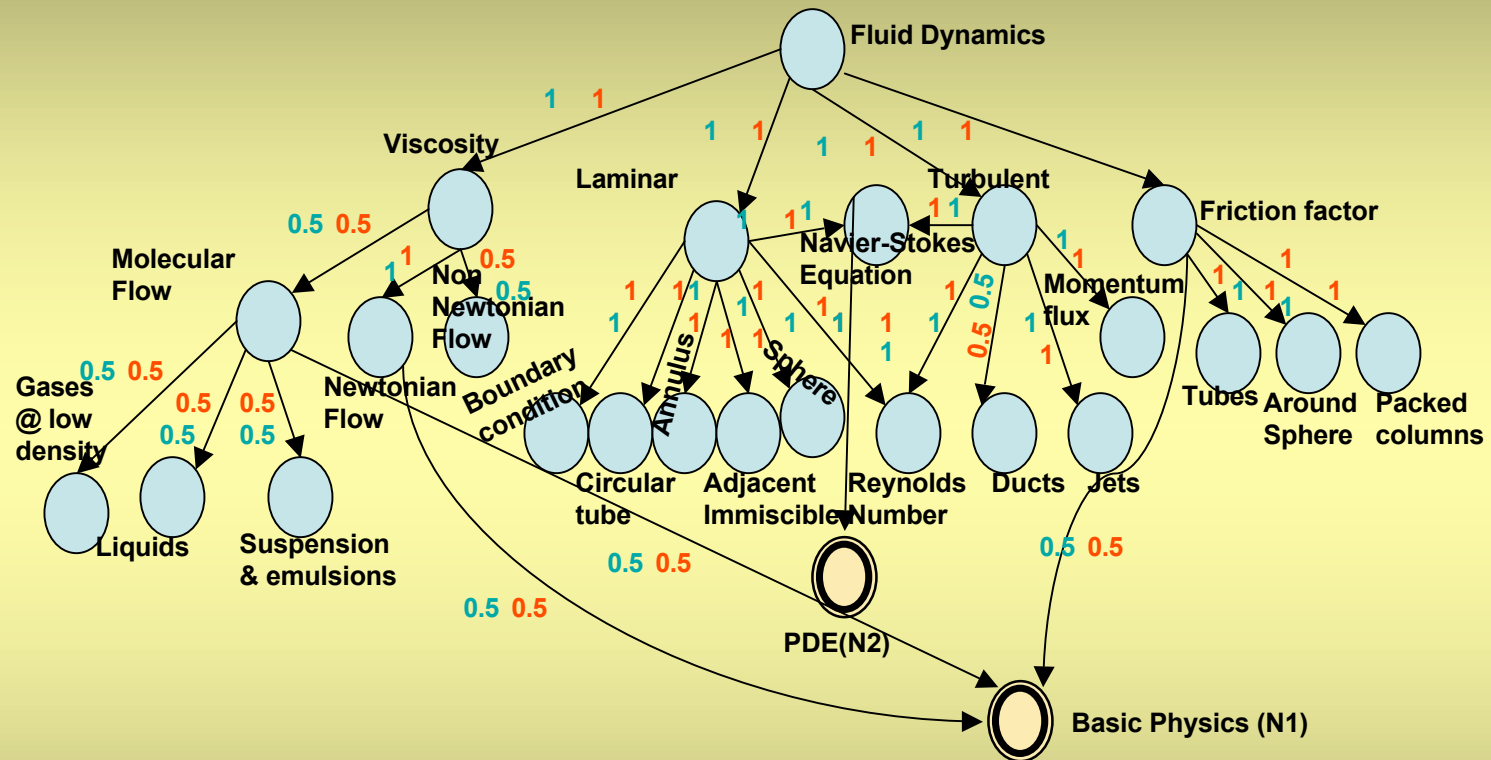
Concept Space: Transport Phenomena



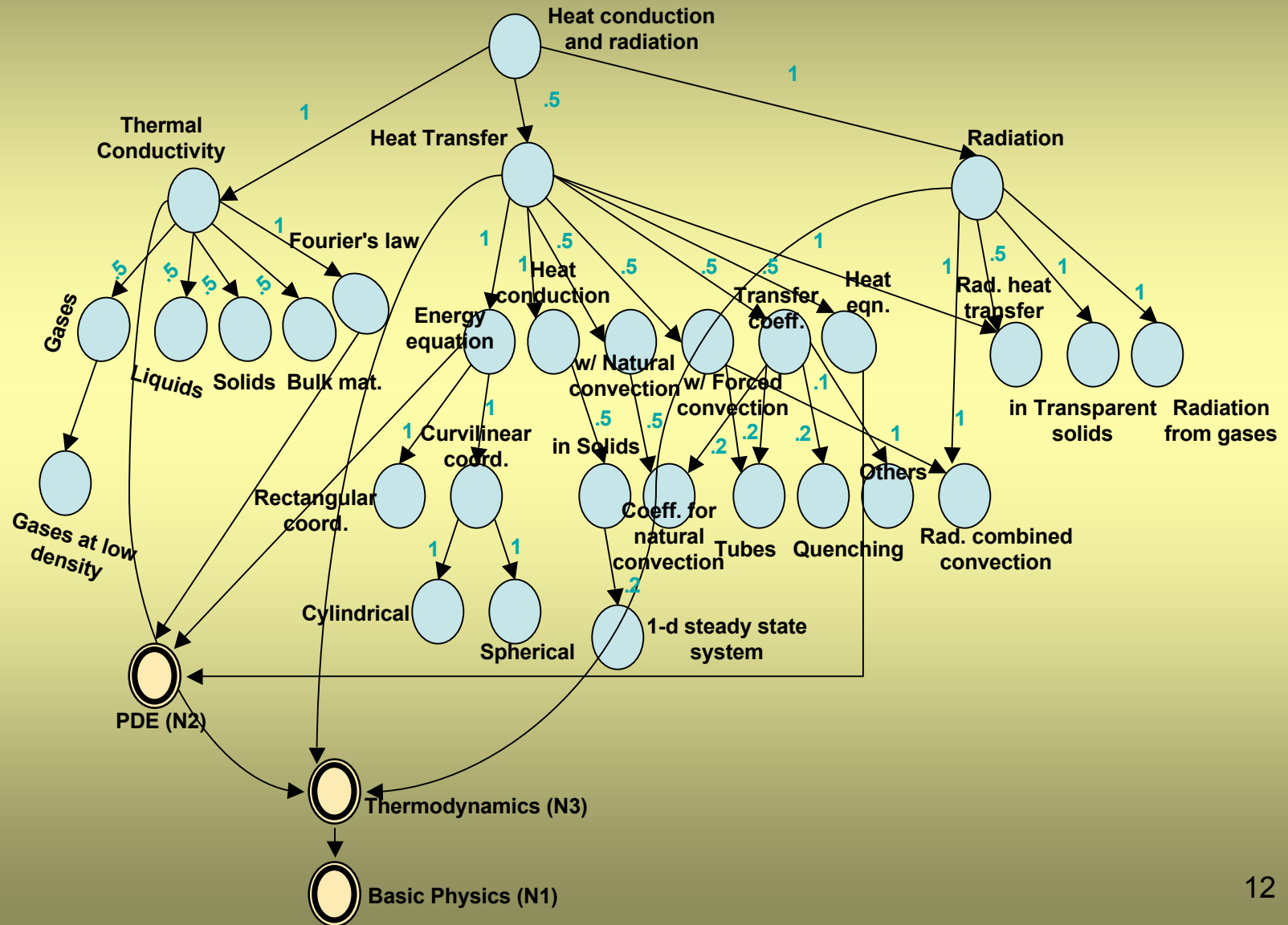
Semantic Topic Graph (part-1)



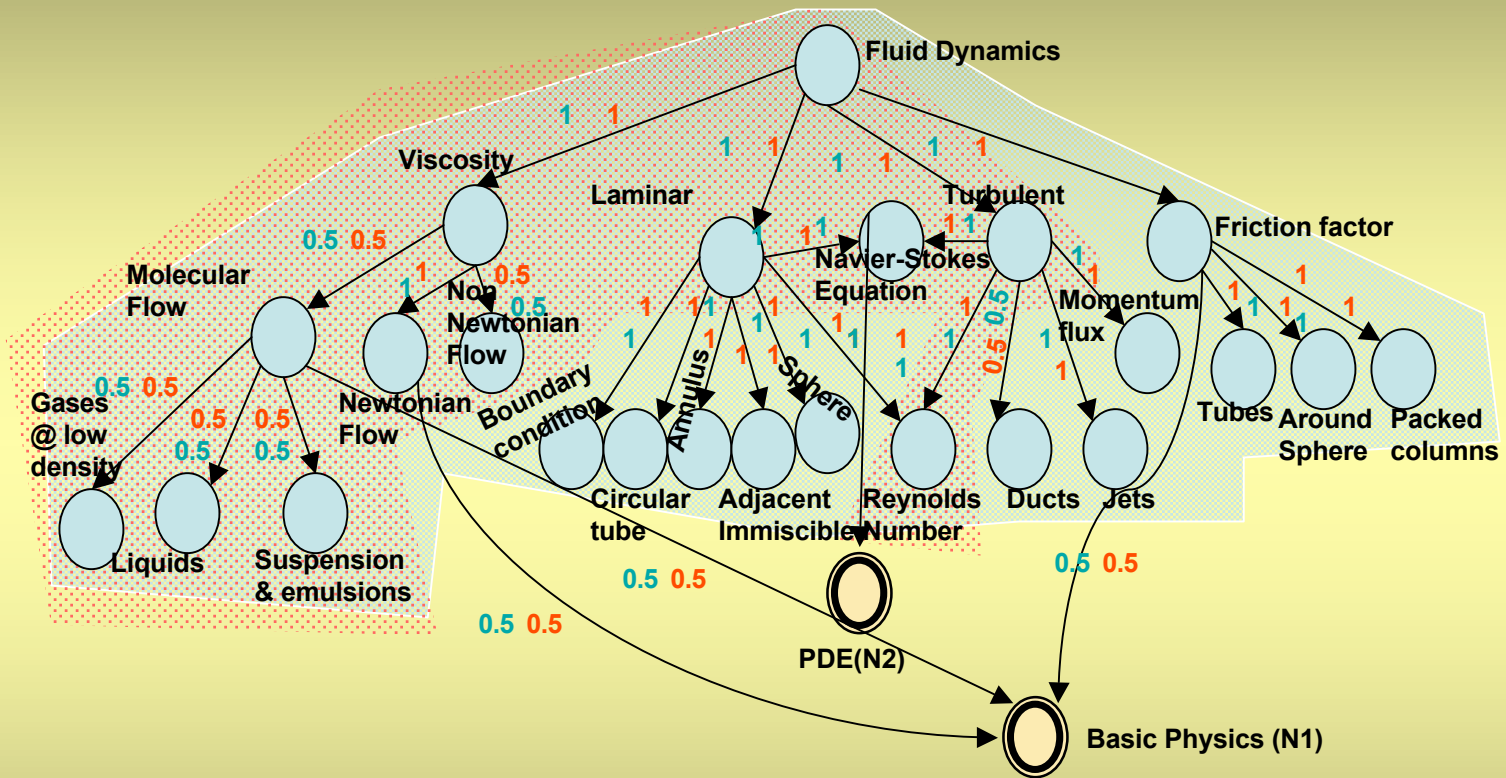
Semantic Topic Graph (part-2)




Semantic Topic Graph (part-3)



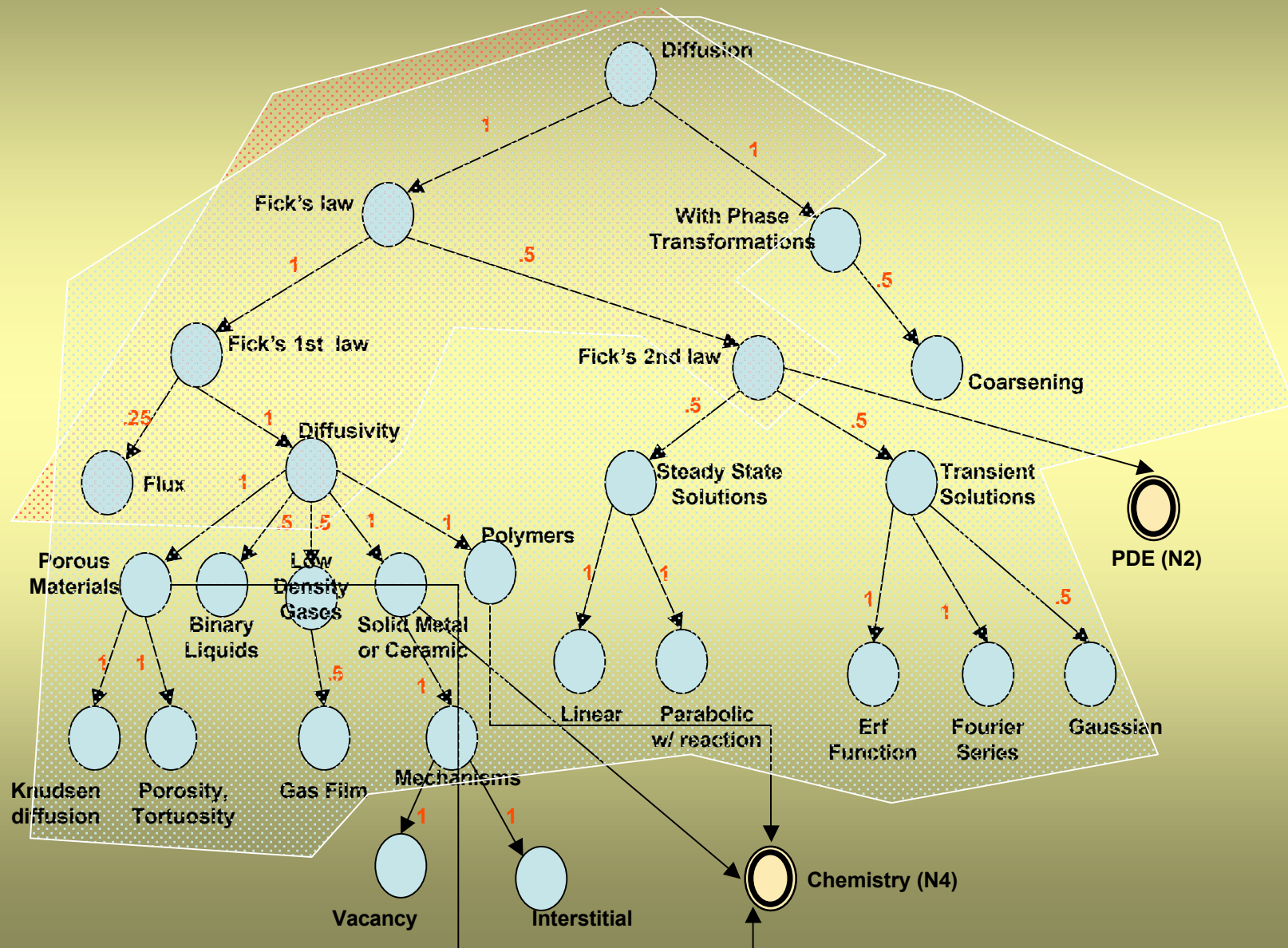
Semantic Topic Graph (part-2)



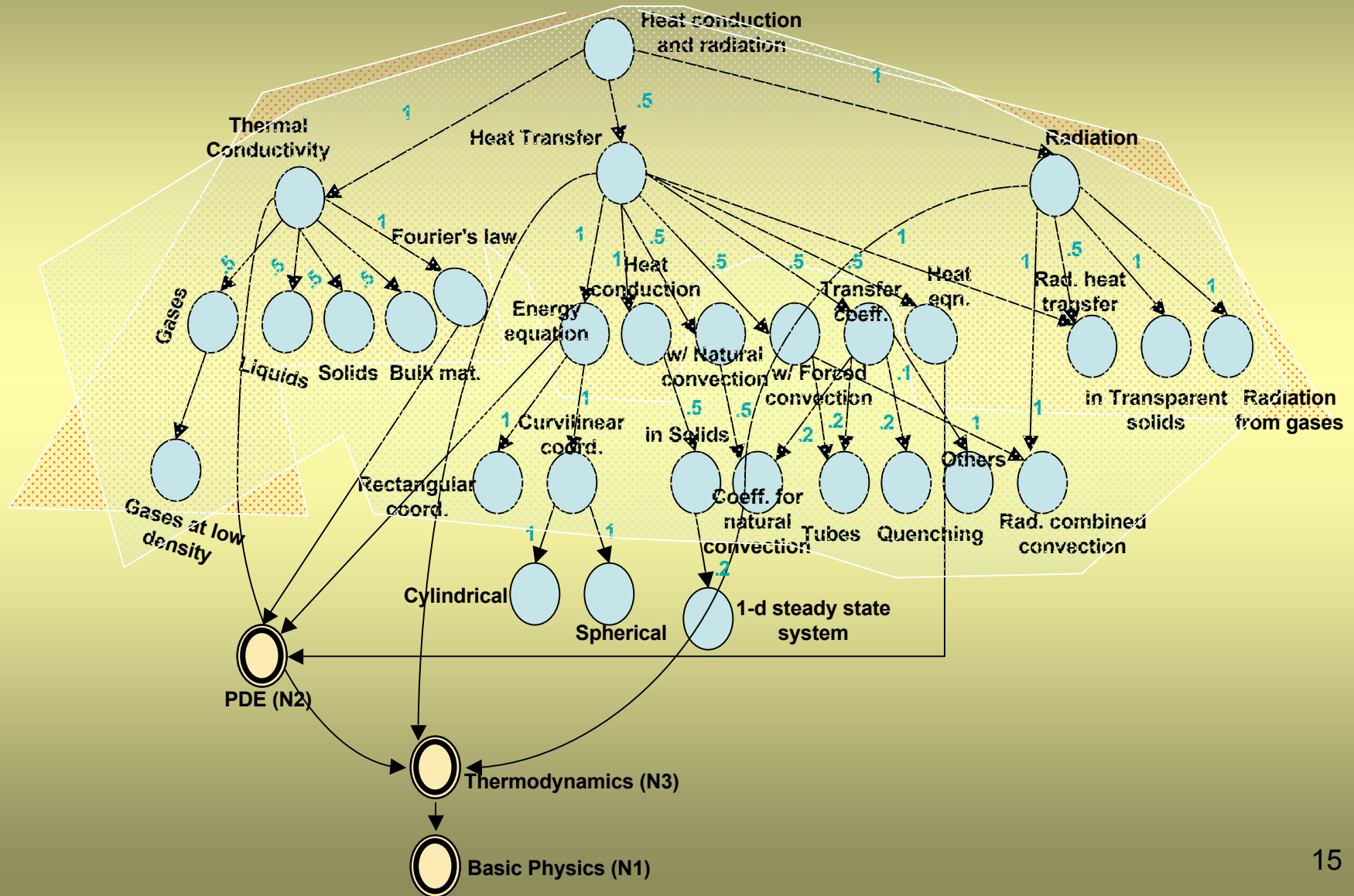
 Physics

 Engineering

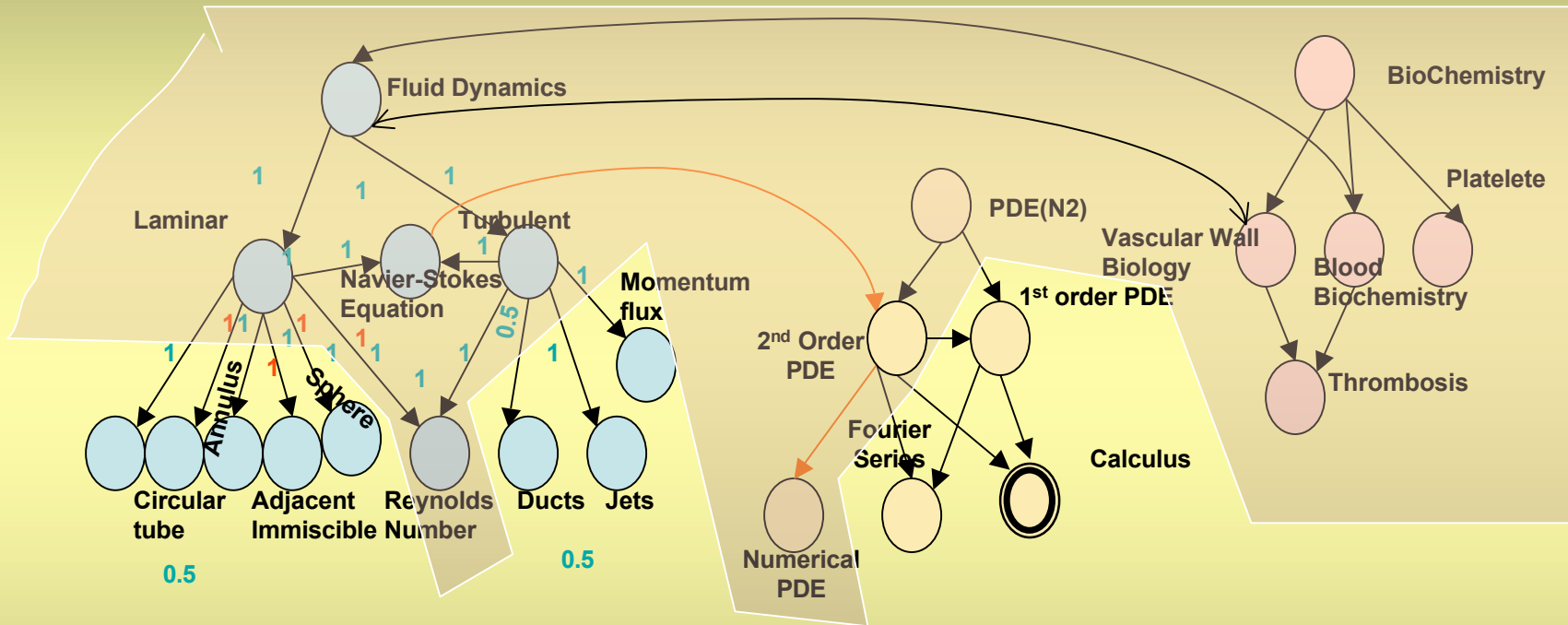
Semantic Topic Graph (part-1)



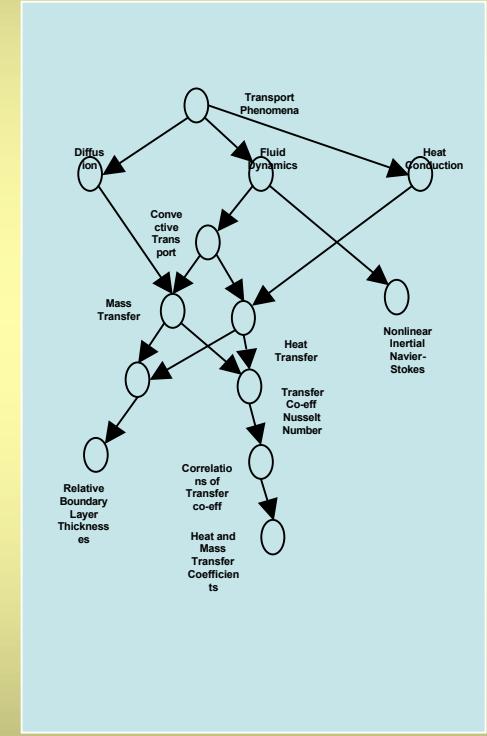
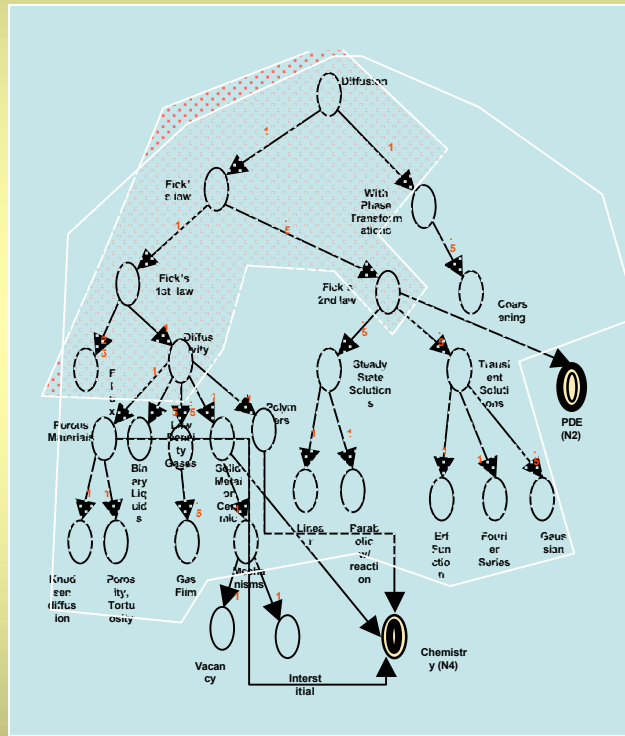
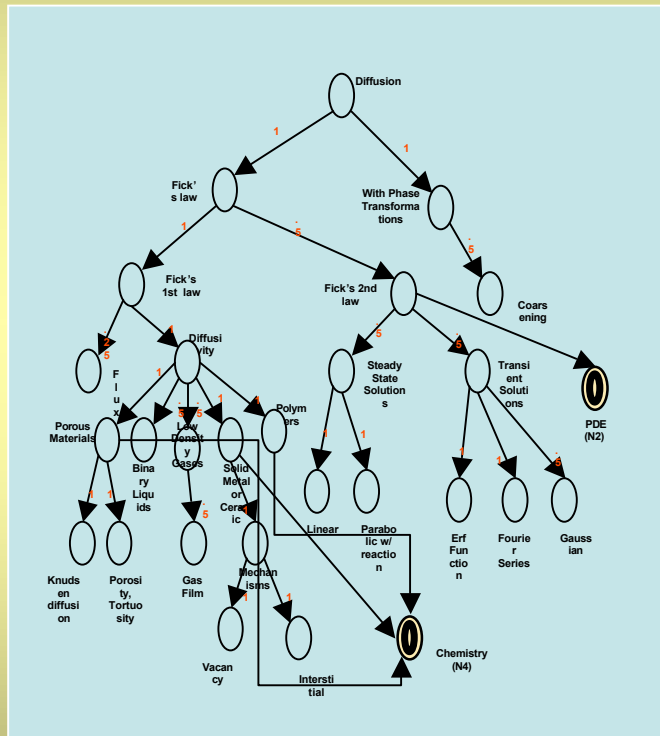
Semantic Topic Graph (part-3)



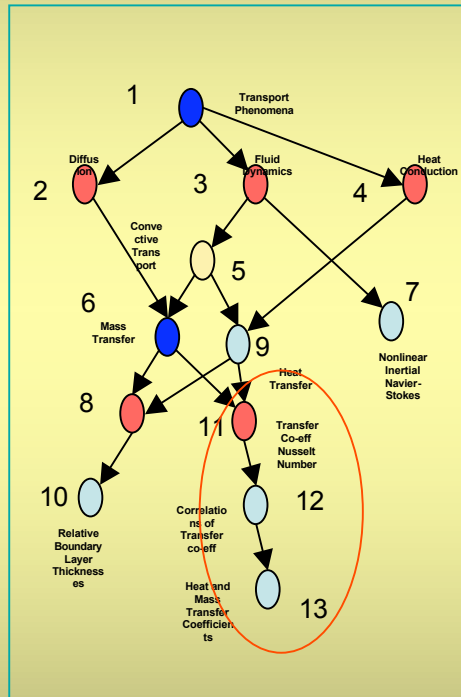
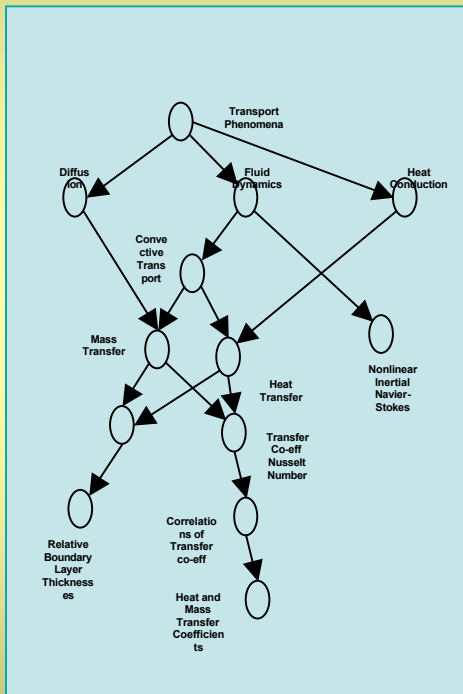
Semantic Topic Graph (Bio-X)



Concept Composition



Linearization



1 → = 1, (2 →), (3 →), (4 →)

2 → = (6 →), 2

6 → = 6, (8 →), (11 →)

8 → = 10, 8

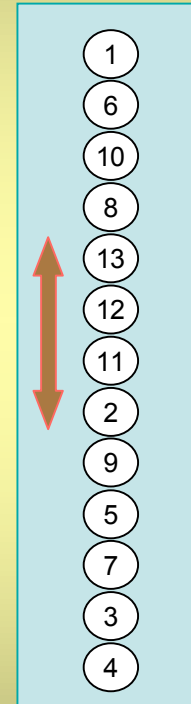
11 → = 13, 12, 11

3 → = (5 →), 7, 3

5 → = 9, 6*, 5

4 → = 4, 9*

1 → = (1, 6, 10, 8, 13, 12, 11, 2, 9, 6*, 5, 7, 3, 4, 9*)



P, L → R



P, R → L

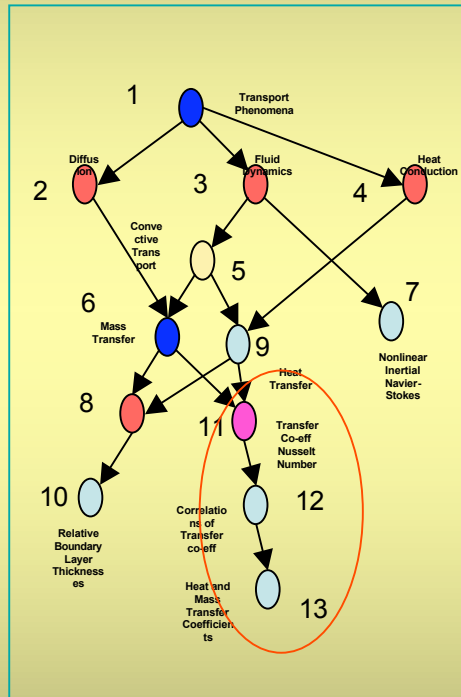
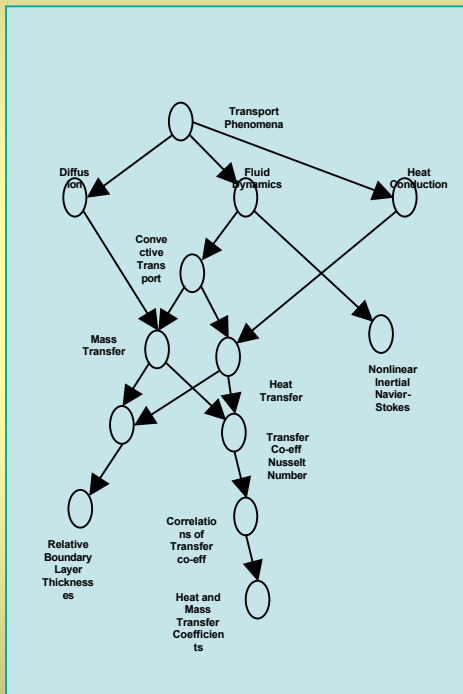


L → R, P



R → L, P

Linearization



1 → = 1, (2 →), (3 →), (4 →)

2 → = (6 →), 2

6 → = 6, (8 →), (11 →)

8 → = 10, 8

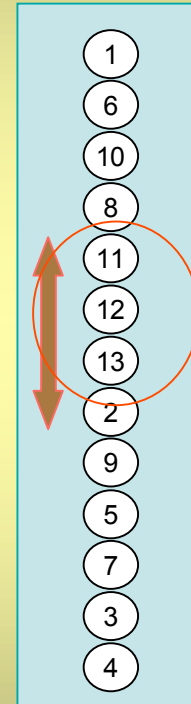
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P, L → R



P, R → L

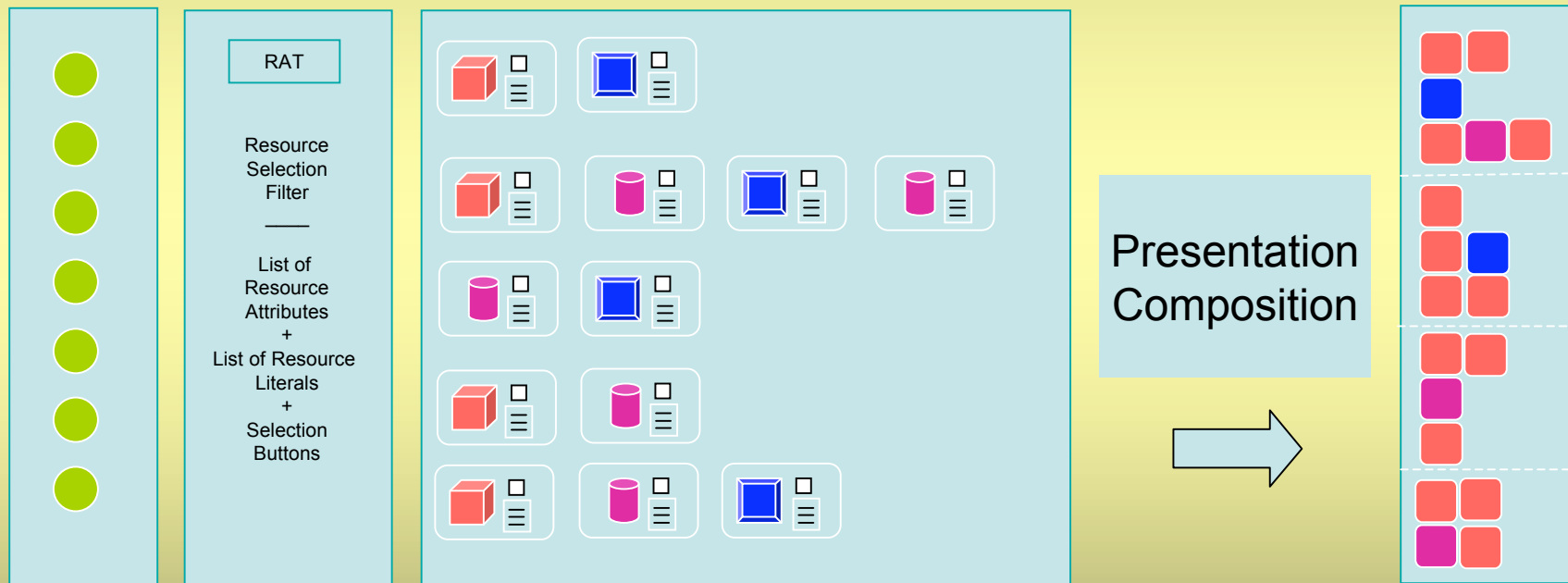


L → R, P



R → L, P

Resource Composition



Challenges

- Flow
 - Pedagogical uniformity
 - Ontological uniformity
 - Seamless use of examples
- System
 - Access to document fragments
 - Third party value added annotation
 - We envision the translation/ conversion onsite. It is scalable in global sense only if the services can be integrated instead.
- Evolution
 - Capturing user's act of design for reuse
- Evaluation
 - How good is a composition?

Future Work

- By April..
 - Topic Composition
 - Linearization
 - Complete Lecture Plan
 - Homework Composition
- What's Possible
 - Creation of all lecture materials!
 - Customized text book
 - Lecture notes
 - Hand notes
 - All tests, exams and assignments
 - Course portal
 - Customized course material for special students (gifted, handicapped, blind)

The authors would like to acknowledge the support of National Science Foundation grant DUE-0333520 and National Institute of Standards and Technology grant 70NANB3H1079.

Thanks!

Question? Feedback? Ideas?