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# Literature Review

**School of Mechanical and Chemical Engineering**

Final Year Project

CHPR 4411/4412

MATE 4411/4412

MECH 4401/4402

MCTX 4421/4422

OGEG 4500/4501

# Starting Out



- Most students start with either little detailed understanding of their project topic, or a narrow understanding based on (limited) experience
- It is important that you develop your understanding of the state of the art in your field as early as possible
  - Your understanding will provide a basis for your project proposal.
  - It enables you to ask well-informed questions of your supervisor, increasing their confidence in your ability to undertake the project successfully.
  - It may help to make additional resources available – it definitely helps you to identify the resources you will need
  - The better (and broader) your understanding, the better the chances are that you will develop a sound project proposal and plan.

# What is a Literature Review?



- The literature review is the first step in any successful research effort.
- The purpose of the literature review is to establish the state of the art in the area that you are working in.
  - For investigative research, this will mean reviewing the academic literature.
  - For design projects, this will mean identifying current approaches to solving the problem of interest (or similar problems)
  - For industrial projects, this will entail reviewing standards and current operating practices.



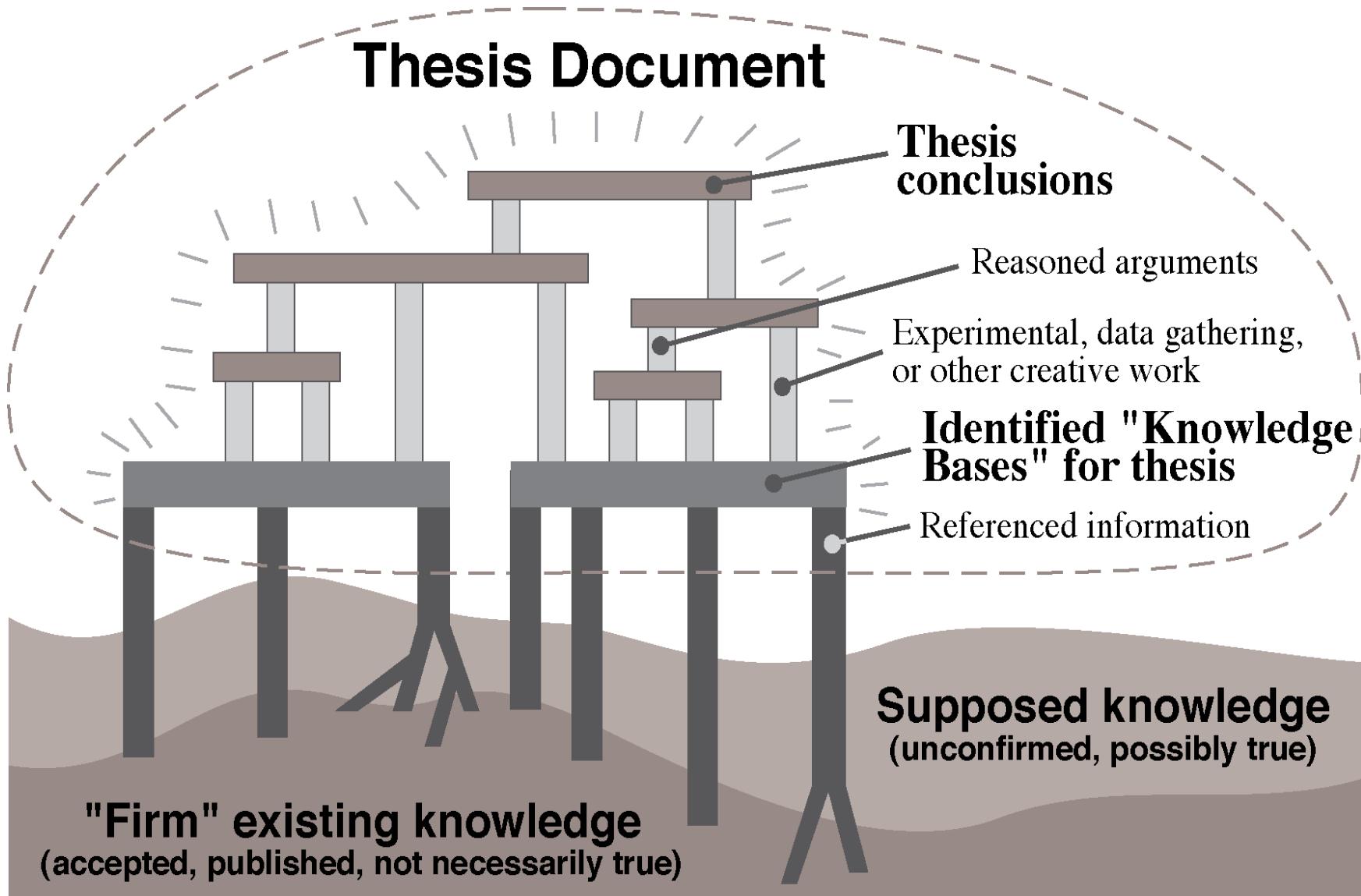
Every statement and conclusion  
in a professional report must be  
supported by accepted literature  
or your results and deductions

# Building a Foundation



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## Thesis Document



# Basic Tools



- Internet search engines have greatly simplified the process of identifying information sources.
- Google, Wikipedia and Media sites can and should be used to provide a quick overview of a field
  - Use to identify relevant publications and experts.
  - Can help with basic definitions or even formulae.
- However, it must be remembered that it is generally **UNACCEPTABLE** to reference these sources in a thesis
  - The reviewing and control of posted data ranges from inconsistent to non-existent.
  - It can be difficult to assess the expertise (or motives) of the poster.

# Expert Materials



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- A research report should rely on peer reviewed and/or edited materials such as
  - Books
  - Scientific Journal Articles
  - Scientific Conference Proceedings
- The UWA library is an excellent research library
  - In addition to the materials in the stacks, there is a wide range of journals available electronically
  - If a particular paper or book is not available, the library can generally locate a copy via inter-library loan relatively quickly. This service (**GETIT**) is free to students enrolled in final year project

# Expert Search Tools



- The library website makes available a variety of web-based search engines/databases that can be used to search for scientific publications and books
  - These tools are much more powerful than the likes of the Google, as they are focused solely on quality scientific publications.
  - They are relatively simple and intuitive to use – you may search by keywords, words in the title, author (essentially the same as when using the library catalogue)
- These may be accessed via the “Supersearch” link on the UWA library’s main web page.
  - Use the “Find Resources” Tab to find specific indexes

# Engineering Databases



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- For engineering, two of the major indexes are “Compendex” and the “Web of Knowledge”.
- Compendex provides a list of papers matching your specified search terms.
  - Access via “Supersearch” link and the “Physical Sciences Option”.
  - Compendex finds both journal papers and conference proceedings (Web of Knowledge focuses on journal papers)
- The “Web of Knowledge” provides a similar capability but can be more powerful because it also provides a Citation Index.
  - The number of citations tells you how influential a paper is.
  - You can follow a “citation trail” from an important paper to research the current state of knowledge in a field.
  - Access via “Supersearch” link and the “Find Resources” tab (Look under “W”).



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# Abstract Page



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Author(s): Skoge M (Skoge, Monica), Donev A (Donev, Aleksandar), Stillinger FH (Stillinger, Frank H.), Torquato S (Torquato, Salvatore)

Source: PHYSICAL REVIEW E Volume: 74 Issue: 4 Article Number: 041127 Part: Part 1 Published: OCT 2006

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**Abstract:** We present a family of disordered jammed hard-sphere packings in four-, five-, and six-dimensional Euclidean spaces. Using a collision-driven packing generation algorithm, we obtain the first estimates for the packing fractions of the maximally random jammed (MRJ) states for space dimensions  $d=4$ ,  $5$ , and  $6$  to be  $\phi(\text{MRJ}) \approx 0.46$ ,  $0.31$ , and  $0.20$ , respectively. To a good approximation, the MRJ density obeys the scaling form  $\phi(\text{MRJ}) = c(1)/2(d) + c(2)d/2(d)$ , where  $c(1) \approx -2.72$  and  $c(2) \approx 2.56$ , which appears to be consistent with the high-dimensional asymptotic limit, albeit with different coefficients. Calculations of the pair correlation function  $g(2)(r)$  and structure factor  $S(k)$  for these states show that short-range ordering appreciably decreases with increasing dimension, consistent with a recently proposed "decorrelation principle," which, among other things, states that unconstrained correlations diminish as the dimension increases and vanish entirely in the limit  $d \rightarrow \infty$ . As in three dimensions (where  $\phi(\text{MRJ}) \approx 0.64$ ), the packings show no signs of crystallization, are isostatic, and have a power-law divergence in  $g(2)(r)$  at contact with power-law exponent approximately to 0.4. Across dimensions, the cumulative number of neighbors equals the kissing number of the conjectured densest packing close to where  $g(2)(r)$  has its first minimum. Additionally, we obtain estimates for the freezing and melting packing fractions for the equilibrium hard-sphere fluid-solid transition,  $\phi(\text{F}) \approx 0.32$  and  $\phi(\text{M}) \approx 0.39$ , respectively, for  $d=4$ , and  $\phi(\text{F}) \approx 0.20$  and  $\phi(\text{M}) \approx 0.25$ , respectively, for  $d=5$ . Although our results indicate the stable phase at high density is a crystalline solid, nucleation appears to be strongly suppressed with increasing dimension.

Document Type: Article

Language: English

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ISSN: 1539-3755

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Author(s): Skoge M (Skoge, Monica), Donev A (Donev, Aleksandar), Stillinger F H (Stillinger, Frank H.), Torquato S (Torquato, Salvatore)

Source: PHYSICAL REVIEW E    Volume: 74, Number: 4, April 2006

Times Cited: 25    References: 53

Abstract: We present a study of disordered packing generation algorithm, we obtain the first estimates for the packing fractions of the maximally random jammed (MRJ) states for space dimensions  $d=4$ ,  $5$ , and  $6$  to be  $\phi_{MRJ} \approx 0.46$ ,  $0.31$ , and  $0.20$ , respectively. To a good approximation, the MRJ density obeys the scaling form  $\phi_{MRJ} = c_1/2^d + (c_2 d)/2^d$ , where  $c_1 = -2.72$  and  $c_2 = 2.56$ , which appears to be consistent with the high-dimensional asymptotic limit, albeit with different coefficients. Calculations of the pair correlation function  $g_2(r)$  and structure factor  $S(k)$  for these states show that short-range ordering appreciably decreases with increasing dimension, consistent with a recently proposed "decorrelation principle," which, among other things, states that unconstrained correlations diminish as the dimension increases and vanish entirely in the limit  $d \rightarrow \infty$ . As in three dimensions (where  $\phi_{MRJ} \approx 0.64$ ), the packings show no signs of crystallization, are isostatic, and have a power-law divergence in  $g_2(r)$  at contact with power-law exponents  $\approx 0.4$ . Across dimensions, the cumulative number of neighbors equals the kissing number of the conjectured densest packing close to where  $g_2(r)$  has its first minimum. Additionally, we obtain estimates for the freezing and melting packing fractions for the equilibrium hard-sphere fluid-solid transition,  $\phi_F \approx 0.32$  and  $\phi_M \approx 0.39$ , respectively, for  $d=4$ , and  $\phi_F \approx 0.20$  and  $\phi_M \approx 0.25$ , respectively, for  $d=5$ . Although our results indicate the stable phase at high density is a crystalline solid, nucleation appears to be strongly suppressed with increasing dimension.

DOI: 10.1103/PhysRevE.74.041127    PACS number(s): 05.20.-y, 61.20.-p, 64.70.Dv, 64.70.Pf

I. INTRODUCTION

Hard-sphere systems are model systems for understanding the equilibrium and dynamical properties of a variety of materials, including simple fluids, colloids, glasses, and granular media. The hard-sphere potential is purely repulsive; it is infinite when two spheres overlap, but otherwise zero. Despite the simplicity of the potential, hard-sphere systems exhibit rich behavior: they undergo a fluid-solid phase transition and can exhibit glassy behavior. Of particular recent interest are (nonequilibrium) disordered jammed packings of

have been made about long-wavelength density fluctuations [25] and decorrelation [27,28] in disordered hard-sphere packings in high dimensions. Additionally, the optimal packing of hard spheres in high dimensions is also of interest in error-correcting codes in communications theory [30].

Our focus in this paper will be the study of hard-sphere packings in four, five, and six dimensions. Specifically, we consider both equilibrium packings for  $d=4$  and  $d=5$  and nonequilibrium packings representative of the maximally random jammed state for  $d=4$ ,  $d=5$ , and  $d=6$ .

Equilibrium thermodynamic properties of hard-sphere

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PHYSICAL REVIEW E 74, 041127 (2006)

Packing hyperspheres in high-dimensional Euclidean spaces

Monica Skoge,<sup>1</sup> Aleksandar Donev,<sup>2,3</sup> Frank H. Stillinger,<sup>4</sup> and Salvatore Torquato,<sup>2,3,4,\*</sup>

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<sup>2</sup>Program in Applied and Computational Mathematics, Princeton University, Princeton, New Jersey 08544, USA

<sup>3</sup>PRISM, Princeton University, Princeton, New Jersey 08544, USA

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(Received 10 June 2006; published 30 October 2006; corrected 16 February 2007)

We present a study of disordered jammed hard-sphere packings in four-, five-, and six-dimensional Euclidean spaces. Using a collision-driven packing generation algorithm, we obtain the first estimates for the packing fractions of the maximally random jammed (MRJ) states for space dimensions  $d=4$ ,  $5$ , and  $6$  to be  $\phi_{MRJ} \approx 0.46$ ,  $0.31$ , and  $0.20$ , respectively. To a good approximation, the MRJ density obeys the scaling form  $\phi_{MRJ} = c_1/2^d + (c_2 d)/2^d$ , where  $c_1 = -2.72$  and  $c_2 = 2.56$ , which appears to be consistent with the high-dimensional asymptotic limit, albeit with different coefficients. Calculations of the pair correlation function  $g_2(r)$  and structure factor  $S(k)$  for these states show that short-range ordering appreciably decreases with increasing dimension, consistent with a recently proposed "decorrelation principle," which, among other things, states that unconstrained correlations diminish as the dimension increases and vanish entirely in the limit  $d \rightarrow \infty$ . As in three dimensions (where  $\phi_{MRJ} \approx 0.64$ ), the packings show no signs of crystallization, are isostatic, and have a power-law divergence in  $g_2(r)$  at contact with power-law exponents  $\approx 0.4$ . Across dimensions, the cumulative number of neighbors equals the kissing number of the conjectured densest packing close to where  $g_2(r)$  has its first minimum. Additionally, we obtain estimates for the freezing and melting packing fractions for the equilibrium hard-sphere fluid-solid transition,  $\phi_F \approx 0.32$  and  $\phi_M \approx 0.39$ , respectively, for  $d=4$ , and  $\phi_F \approx 0.20$  and  $\phi_M \approx 0.25$ , respectively, for  $d=5$ . Although our results indicate the stable phase at high density is a crystalline solid, nucleation appears to be strongly suppressed with increasing dimension.

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Equilibrium thermodynamic properties of hard-sphere

# Approach



- Remember that the word “review” is important – it is not a literature “survey”
- It is essential to read the material you find carefully and critically.
  - Does the material apply directly to your work?
  - What are the limitations of the published material?
- A good paper or book will usually be well referenced – the reference lists can help you find older, more fundamental work in a field
  - A good literature review will evolve and expand from each paper you review.
  - Fundamental papers can often make it easier to understand the topic you are researching

# Approach



- IMPORTANTLY - do not limit your consideration of literature to recent works.
  - Fundamental papers and texts can often make it easier to understand a particular technique or approach.
  - In seminal papers, the jargon of the field has usually not yet developed – so the text is often more comprehensible
  - The basis and limits of a particular approach can also often be more clearly identified in the original papers.

***So don't ignore the dusty old journals! In many fields, the basis of current thinking was laid out a long time ago.***