Name:

Tutor:

PH30028 – Real solids, surfaces and soft matter physics

COURSEWORK ASSIGNMENT - issued April 2008

Answers to the following question, with this sheet firmly attached as a cover sheet, should be handed in to the box marked "PH30028 -- Real solids, surfaces and soft matter physics" to be found just inside the door of the Undergraduate Physics Laboratory (3W3.19) by 5pm on Fri 2nd May 2008.

Following standard practice in the Department of Physics, work handed in late will lose 20% of all available marks for each 24 hours (or part thereof) past the deadline.

Note that some marks are awarded for presentation. Full marks will be awarded for work which correctly answers the questions, with sketches that are suitable drawn and annotated, and with answers logically structured with a concise explanation of the mathematical steps performed. Marks will be lost for work which just gives intermediate and/or final results, or consists of pages of algebra without explanation.

The marks available for this piece of assessed work are 50% of the total coursework mark for this unit.

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3W2.8(a)

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1(a) Find an expression for the end-to-end distance of maximum probability, for a self-avoiding walk if the probability for a walk of length R is given by,

$$W(R) = cR^2 \exp\left(-\frac{3R^2}{2Nb^2} - \frac{N^2 V_1}{2R^3} \right)$$

where c is a constant. Express you answer in terms of the mean square end-to-end distance of the chain.

1(b) The free energy of a self-avoiding chain as a function of extension, R, is sometimes written

$$F(R) = cT\left(\frac{3R^2}{2Nb^2} + \frac{N^2 V_1}{2R^3} - 2\ln R \right)$$

How can this be obtained using the Boltzmann probability and the function given above?

2) It is suggested that the mean squared end-to-end distance of real (i.e. non-intersecting) polymer chains can be represented by $< \underline{R}^2 >= b_0^2 N^{2\nu}$ where N is the degree of polymerisation, b_0 is the bond length between successive monomers in the chain, and ν is a scaling exponent which characterises the N dependence. To test this hypothesis, computer simulations were performed in which self-avoiding walks were generated on a square lattice, a cubic lattice and a hypothetical 4-dimensional hyper-cubic lattice. The results are given below. All dimensions are quoted in lattice units.

N	$<R^2>$ Square lattice	$<R^2>$ cubic lattice	$<R^2>$ 4-d lattice
2	2.6667	2.4	2.2856
4	7.0404	5.5535	5.0322
8	19.009	12.855	10.941
16	52.037	29.675	23.553
32	161.81	68.384	50.128
48	–	112.9	77.524
64	–	–	109.81

Use graphical means to determine the exponent ν in each case. Do the polymer chains become more or less ideal (Gaussian) as the number of dimensions increases? Discuss why this might be the case.