http://www4.tpgi.com.au/nanahcub/submission.pdf

Submission for Stage 6 Syllabus Review, 2006

By Derek Buchanan

Announcement

The syllabus will be changed by 2010 as announced at the 2005 MANSW Conference (Board of Studies, 2005).

This is happenning in the following phases in accordance with the Board of Studies' *Syllabus Development Handbook* (Board of Studies, 2003b):

- Syllabus review: evaluate, consult, research, recommend.
- Writing-brief development: write brief, consult, identify issues, revise brief.
- Syllabus development: draft; consult; address issues; report on meeting Board criteria; modify; to Curriculum Committee, then Board, then Minister; brief schools; distribute.
- Implementation.

Timeline

Syllabus Review: Mar - Dec 2006
Writing Brief Development: Jan - Jul 2007
Syllabus Development: Aug 2007 - Nov 2008
Implementation: Probably from 2010

(Board of Studies, 2006)

Forum

The Board of Studies is inviting submissions from individuals and associations in the current review of Stage 6 Mathematics:

http://www.mansw.nsw.edu.au/whatsnew/stage-6-forum.html

Thursday 1st June, 2006
MANSW Office, Kent Rd, Eastwood
4.30pm Afternoon Tea
5pm - 7pm Discussion

Syllabus Review

Calculators

- Graphics calculators should not be mandated for use at the HSC.
- Use of scientific calculators should be mandated.

- Graphics calculators and computer algebra system calculators should be available for optional use.

General Mathematics

Delete this subject. Although this is quite a popular subject, any maths course after Year 10 should include calculus. So students who currently are doing General Mathematics should be doing 2 Unit Mathematics instead.

2 Unit/Extension 1

Preamble

Contents: Keep this, but add an index and list of references.

Course Descriptions: Preliminary Course/HSC Course division is unnecessary, too restrictive and prescriptive. Unlike other subjects, the preliminary section is examinable at the HSC exams so this division should be abolished.

Part A: This can be included in the Contents section.

Preface: Simplify "mathematics Syllabus 3 Unit and 2 Unit Courses" down to just sections "The 2 Unit Course" and "The 3 Unit Course":

The 2 Unit Course:

"The content and depth of treatment of this course indicate that it is intended for students who have completed the School Certificate mathematics course and demonstrated general competence in all the skills included in that course. The 2 Unit course is intended to give these students an understanding of and competence in some further aspects of mathematics. The course has general educational merit and is also useful for concurrent studies in science and commerce. It is a sufficient basis for further studies in mathematics as a minor discipline at tertiary level in support of courses such as the life sciences or commerce. Students who require substantial mathematics at a tertiary level supporting the physical sciences, computer science or engineering should undertake the 3 or 4 unit courses." (Board of Studies, 1982)

The 3 Unit Course:

"The content of this course, which includes the whole of the 2 Unit course, and its depth of treatment indicate that it is intended for students who have demonstrated a mastery of the skills included in the School Certificate mathematics course and who are interested in the study of further skills and ideas in mathematics. The 3 Unit course is intended to give these students a thorough understanding of, and competence in, aspects of mathematics. The course has general educational merit and is also useful for concurrent studies of science, industrial arts and commerce.

It is a recommended minimum basis for further studies in mathematics as a major discipline at a tertiary level, and for the study of mathematics in support of the physical and engineering sciences. Although the 3 Unit course is sufficient for these purposes, it is recommended that students of outstanding mathematical ability should consider undertaking the 4 Unit course." (Board of Studies, 1982)

Format

The † sections indicating students need not reproduce proofs of some parts and E sections with boxes surrounding it indicating Extension 1 material should continue. The 2 Unit and Extension 1 syllabuses should continue to be published together and not as separate syllabuses.

Topics $1 - 18$

Delete topics 3 and 18 and replace them respectively with Number Theory and Complex Numbers (2.1-2.4 from Extension 2 syllabus).

1. Basic Arithmetic and Algebra

As Extension 1, include Surdic equations and square roots of binomial surds, proofs of fundamental theorem of arithmetic, irrationality of $\sqrt{2}$, infinitude of primes and rationalising the denominator in $\frac{1}{\sqrt[3]{2}-1}$.

2. Plane Geometry

To be consistent with the new 7-10 syllabus, include constructions (Board of Studies, 2003a) and the British definition of trapezium. This definition should explicitly be given because there are currently 3 popular conflicting definitions in common use:

American trapezium: quadrilateral for which no 2 sides are parallel
Chinese trapezium: quadrilateral for which only 1 pair of sides are parallel
British trapezium: quadrilateral for which at least 1 pair of sides are parallel

Choosing the British definition allows a parallelogram to be a type of trapezium whereas the Chinese and American definitions don't.

The relationship between Euclid's parallel postulate and the results for alternate, corresponding and cointerior angles for parallel lines should be given. The term "allied" angles should be deleted from the syllabus. A proof of Pythagoras' Theorem using similar triangles is not necessary. There are many ways to prove it and it should be at the teacher's discretion as to which method to use. Abbreviations should be allowed, eg., alt. for alternate.

3. Probability

Delete this topic and replace it with Number Theory.

4. Real Functions of a Real Variable and Their Geometrical Presentation

Proper function notation should be used. Surjections, injections and bijections and corresponding notations should be explained and used. Include the cubic formula in 2 Unit for x-intercepts of cubic graphs. The syllabus states "The concept of a function defined on an abstract set and formal definitions involving such functions are not required in this course". They should be!

5. Trigonometric Ratios − Review and Some Preliminary Results

Include as Extension 1, sums to products and products to sums, solution of trangles and tangent rule. Include as 2 Unit, Heron's formula.

6. Linear Functions and Lines

In 6.8 it states "Examples, illustrating the use of coordinate methods in solving geometrical problems are to be restricted to problems with spectified data". This statement should be deleted from the syllabus. Theoretical examples can be included as well.

7. Series and Applications

For section 7.5, general formulae for superannuation and time payments can be derived and subsequent examples can use these formulae and there is no need to do "step-by-step" solutions for each example.

Induction mantras are published in a lot of the literature and also a lot of the literature omits it. Such mantras (e.g., it is true for $n = 1$ $\therefore$ it is true for $n = 2$ $\therefore$ it is true for $n = 3$, etc., i.e., by induction it is true for all positive integers n) are unnecessary. So although the syllabus omits it, as it should continue so to do, nevertheless it should state that such mantras are not to be written in the examinations and that textbooks extolling their use can be safely ignored.

8. The Tangent to a Curve and the Derivative of a Function

The formal definition of limit should be done. There is no point in pretending to be rigorous defining a derivative as a limit when the definition of limit is only "intuitive".

9. The Quadratic Polynomial and the Parabola

The section of a cone whose plane is parallel to one of its generators can be proved via a Dandelin sphere to be a parabola and this should be done in 2 Unit.

10. Geometrical Applications of Differentiation

Include third derivative test for verifying inflections. Second and third derivative tests are sufficient but not necessary, yet they can be generalised to the successive derivative test which is sufficient and necessary. Section 10.8 (primitive functions) should be moved to topic 11 (integration). Include Newton's method in 2 Unit.

11. Integration

Include the formal definition of Riemann integral and integration by first principles.

Notation $[F(x)]_a^b = F(b) - F(a)$ should be included in section 11.2 of the syllabus. There is a typographical error in the syllabus in 11.2(ii):

$\int_a^b f(x)\,dx + \int_b^c f(x)\,dx - \int_a^c f(x)\,dx$

which should be

$\int_a^b f(x)\,dx + \int_b^c f(x)\,dx = \int_a^c f(x)\,dx$

Delete trapezoidal rule. If Simpson's rule gives better estimates, there's no need at all for trapezoidal rule.

12. Logarithmic and Exponential Functions

Delete sections 12.4(a)-(d). The method in 12.4(e) is more rigorous to define $\ln x$ and this is the method which should be used. Lagarias equivalence to the Riemann Hypothesis can be included here and a calculator exercise can be done to verify it for small values of $n > 1$:

$\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{n} + e^{\frac{1}{1}+\frac{1}{2}+\frac{1}{3}+\cdots+\frac{1}{n}} \ln(\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{n}) >$ sum of divisors of n

A \$1,000,000 prize exists for its proof at www.claymath.org.

13. The Trigonometric Functions

Include the formula for area of a sector, given the radius and arc length, $A = \frac{1}{2}rl$.

14. Applications of Calculus to the Physical World

Include the formal derivation of solutions to equations $\frac{dN}{dt} = k(N - P)$ and $\frac{d^2x}{dt^2} = -n^2(x - b)$.

15. Inverse Functions and the Inverse Trigonometric Functions

Include $\sec^{-1} x$, $\text{cosec}^{-1} x$ and $\cot^{-1} x$ and their derivatives and integrals and also integrals of $\sin^{-1} x$, $\cos^{-1} x$ and $\tan^{-1} x$.

16. Polynomials

Include the cubic formula and proof of Fermat's Last Theorem. Halving the interval method can be deleted and Newton's method (section 16.4(ii)) can be moved to topic 10 for 2 Unit.

17. Binomial Theorem

Include proof by calculus. Include factorial notation in topic 17. In section 17.3 is says "The substitution, $x = 1$, in the expansion of $(1 + x)^n$ gives the formula $2n = \sum_{k=0}^{n} \binom{n}{k}$." This should be $2^n = \sum_{k=0}^{n} \binom{n}{k}$

It then says in brackets "(This can, of course, be given a direct combinatorial interpretation as the equality of two methods of enumerating the subsets of a set of n elements)"

Of course, this comment should be deleted from the syllabus.

18. Permutations, Combinations and Further Probability

Delete this topic. Replace it with 2.1-2.4 of the Complex Numbers part of the Extension 2 syllabus.

Extension 2

Preamble

Contents section should be included, but also an index and list of references should be added.

The sections "Mathematics K-12 Statement of Principles" and "The Mathematics 4 Unit Syllabus" can be deleted and simplified to a shorter Preface like the "Introduction" in "The Mathematics 4 Unit Syllabus":

"The Mathematics 4 Unit course is defined in the same terms as the 3 Unit Course in other subjects. Thus it offers a suitable preparation for study of the subject at tertiary level, as well as a deeper and more extensive treatment of certain topics than is offered in other Mathematics courses. This syllabus is designed for students with a special interest in mathematics who have shown that they possess special aptitude for the subject. It represents a distinctly high level in school mathematics involving the development of considerable manipulative skill and a high degree of understanding of the fundamental ideas of algebra and calculus. These topics are

treated in some depth. Thus the course provides a sufficient basis for a wide range of useful applications of mathematics as well as an adequate foundation for the further study of the subject." (Board of Studies, 1989.)

Topics $1-8$

All topics should be kept, but 2.1-2.4 should move to the Extension 1 Syllabus.

Format

"Contents & Skills Objectives" and "Applications, Implications & Considerations" sections can be combined into a single "Content" section with examples for each topic.

Topic 1 – Graphs

Transformations of given curves without knowing the formula should be given.

Topic 2 – Complex Numbers

2.1-2.4 can go into the Extension 1 syllabus and we can keep 2.5 in Extension 2. Also include field properties, ordered pairs, Euler's formula, proof of de Moivre's theorem via Euler's formula, rational linear transformations of circles and lines and a more truthful historical account of the genesis of complex numbers from solutions of cubics - not quadratics.

Topic 3 – Conics

Include locus problems on ellipses and hyperbolae, general conic and proof using Dandelin spheres that sections of a cone are parabolas, circles, ellipses and hyperbolae.

Topic 4 – Integration

Include recurrence relations involving more than one integer parameter, arc length, surface area of revolution and integration by first principles.

Topic 5 – Volumes

It should be OK to write a volume as an integral without a limiting argument. This is accepted in Extension 1 and should also be so in Extension 2, eg., $\int_a^b 2\pi xy\,dx$ for cylindrical shells. Derive it once and thereafter there is no need to keep re-deriving it every time one uses it.

Topic 6 – Mechanics

Include momentum, energy and coefficient of friction.

Topic 7 – Polynomials

Include proofs of fundamental theorem of algebra and Fermat's last theorem, cubic and quartic formulae and partial fractions with multiple factors in the denominator and integrals thereof.

Topic 8 – Harder 3 Unit Topics

Examples should be provided for all Extension 1 topics.

Issues for Syllabus Development

Under the onslaught of syllabus changes over the last 30 years only mathematics survives with its integrity unchallenged (Devine, 2004). In other subjects, in the age of the knowledge economy, we have somehow managed to combine the widest ever participation in higher education with the most dumbed-down of cultures (Furedi, 2004). We have to ensure that this doesn't happen to the maths syllabus. Nevertheless, scaling up of marks in HSC maths has led to a perception that standards are falling (eg., Linkiewicz, 2005).

The history of maths should be included.

Some would say that assessment and curriculum are separate issues. I disagree. The current 4 unit syllabus quotes past papers! External exams started in 1916 for the NSW Leaving Certificate preceeded by entrance exams for Sydney University. We should continue to have external exams and not go with 100% internal assessment like in Queensland.

A national curriculum was attempted 12 years ago and was a disaster. If you just look at the content and forget about the flowery platitudes, our current NSW syllabus was deemed much better. Unless the Australian Constitution is changed to abolish the states and territories, I doubt this agenda will get very far whenever it raises it's ugly head. There are concerns about lowering of NSW standards through any move to a national certificate (Patty, 2006). Future arrangements must add value to what exists and certainly must not lead to any reduction in quality or standards (Masters, 2006). OK. I'm not going to change my website www.fourunitmaths.cjb.net in any way whatsoever (unless Geoff Masters proves the Riemann Hypothesis - but I won't hold my breath for that).

A more internationally competitive syllabus might have to compete with IB, the Singapore syllabus, English A levels etc. But there is a lot of overlap between our current syllabus and these courses. The major difference is that the higher levels include statistics, whereas in NSW we have relegated statistics to the lowest level only, i.e., General Maths. We should not want statistics to be added to the 4 unit course. Introducing statistics and technology could downgrade the calculus study to a mathematics appreciation course (Doherty, 2005).

In his review of the HSC, Barry McGaw recommended that the 4 unit course be abolished. The Government White Paper adopted most of his recommendations, but I'm glad that this is one of them the Government rejected. I would like for the 4 unit course to remain.

In 1981 the 4 unit syllabus was dumbed down to become a 1-year course. Level 1 was better. It started in 1966 as a 2-year course and continued as such until 1980.

When the HSC started in 1966, replacing the Leaving Certificate (which only went up to Grade V, i.e., Year 11), Grade VI (Year 12) was added and the first incarnation of 4 unit maths (Level 1) was a 2 year course. In 1981 they dumbed it down to a 1-year course and it's been a 1-year course ever since.

Level 1 was better than the old Honours I Leaving Certificate course which ran from 1916-1966. It was also better than the current 4-unit course. Subsequently they also had to dumb down 1st year uni maths, which many academics were not very happy about. So many people want the 2-year course back.

The only excuse for why the harder Level 1 course can't be taught in high schools again, is teacher incompetence. And that's a very poor excuse.

Here are the topics previously in the course which have been removed, but many people want back (although I would argue against bringing back applications of matrices to probability):

Leaving Certificate (1916-1966)

- 3rd derivative test for inflections
- Substitution $x = a\cos^2\theta + b\sin^2\theta$ for $\int \sqrt{(x-a)(x-b)}dx$, $\int \frac{1}{\sqrt{(x-a)(x-b)}}dx$, $\int \sqrt{\frac{(x-a)}{(b-x)}}dx$
- Euler's Formula
- Integration as a summation
- Determinants and solutions of equations
- Convergence and divergence of infinite series
- Logarithmic and Exponential series and Euler's constant
- Binomial series for fractional or negative index.

Level 1 (1966-1980)

- Euclidean algorithm
- Proof of the fundamental theorem of arithmetic
- Determinants and the solution of equations and area of triangle
- Geometry of matrices
- Geometrical transformations using matrices
- Algebra of matrices

- Rolle's theorem and mean value theorem
- Integration as summation
- Euler's formula
- Length of arc
- Group theory, isomorphism
- Applications of matrices to geometry and probability
- Work, Kinetic Energy, Potential energy
- Convergence and divergence of infinite series
- Riemann Zeta function
- Logarithmic and exponential series
- Series for $\sin x, \cos x, \tan^{-1} x$
- Taylor's series.

Level 2F (1966-1982)

- Mid-ordinate rule
- Change of coordinate systems - transformations
- Analytical geometry in three dimensions

Quite a lot of this stuff which used to be taught in school, is now postponed till university in Australia. However, other countries are still teaching it in school. So Australia is seen as a bit behind the rest of the world, particularly in regard to school maths and 1st year uni maths.

If we bring these topics back and make 4 unit a 2-year course again, we won't have to postpone them till university, and perhaps the uni's can then focus on what they should be doing and not have to teach what should have been done in school, as they currently do.

Graphics calculators were used by 5% of General Mathematics students in the 2004 HSC and their use did not demonstrate any significant improvement in their understanding of maths. These should not be allowed in the HSC exams for 4 unit because they would adversely affect assessment of topics like Graphs. They are not needed.

There is currently a strong emphasis on calculus in the 2/3/4 unit courses and this strong emphasis should continue.

We also have a strong emphasis on Geometry, especially in regard to proofs. Euclid gave Number Theory equal importance as Geometry, yet our syllabus is almost devoid of Number Theory. We should include Number Theory in a new syllabus.

Probability has traditionally been in the courses. It has been there since the Leaving Certificate in 1916. It isn't needed. We could get rid of probability without causing too much damage.

"Just stick to the syllabus and don't ever do anything outside the syllabus". I have never heard anyone from the syllabus committee say this. It usually comes from unqualified (or worse, minimally qualified) teachers. Better teachers extend their students beyond the syllabus (for example, Palmer, 2005). Bill Pender and Jim Coroneos were on the syllabus committee and yet their 3 unit and 4 unit books contain heaps of stuff not in the syllabus. Likewise for Parabola magazine, Mathematics Enrichment Groups and Olympiad teams, etc. If it's good enough for them to reach beyond the syllabus, then surely it is good enough for the rest of us. Whenever pathetic teachers who can't see past their nose say "Just stick to the syllabus and don't ever do anything outside the syllabus" to me, I just say to them they can stick their syllabus in the bin. The maths syllabus should not be prescriptive as it is in other subjects. It should not confine teachers to the compartment of a teachers discipline sanctioned by the Board of Studies because offered such an intellectually stultifying role, very few top graduates will persue a career in secondary education (Brass, 2006).

In 1999, over 200 mathematicians (including Nobel prize winners and Fields Medallists) signed a petition to the then United States Secretary of Education. So-called *experts* involved in curriculum development at school level were slammed on the head and were in no uncertain terms made to look by these Nobel Prize winners and Fields Medallists as demonstrably INEXPERT! These amateurs go to conferences to push their rubbish pretending to be professional, but really don't know what they are talking about (Hayes, 2005). The US Math War is relevant to NSW because a lot of the rubbish promulgated by the so-called *experts* in NSW is the same rubbish coming from the US. According to Professor Kaye Stacey's report "Review of Senior Secondary Mathematics Curriculum", we should maintain rigour and proofs. The Board Curriculum Committee would do well to read the petition before they make ANY changes at all to the current syllabus (Klein et al., 1999).

The training of school teachers had become dominated by social theorists in education faculties who don't have a strong understanding of the unique nature of subjects like maths. So there's a very large number of people teaching maths in schools who have little understanding, motivation or love for it, so they're not teaching it well and not motivating students to be interested (O'Keefe, 2006).

So although school maths used to be a crucible of excellence, now it has become a sentinel of mediocrity.

I'm not advocating that we just bring back all the old topics. Many of them would be good to bring back, eg., determinants. I've also advocated in the past that some stuff which has always been there to be deleted, eg., probability. Also I think we should bring in stuff which has never been there, eg., Number Theory.

The idea is to make 4 unit a 2 year course again, and not necessarily to make it "harder".

Anyway, the old Level 1 course prepared students for 1st year better and you could

start 1st year at a higher level than the current 1st year courses - as they once were before the disasterous dumbing down which occured in the early 1980's.

This may seem to be just harking back to the past, but actually it's not. We could also compare the current situation with other countries.

Compared to other states' maths syllabuses the current 4 unit course comes out on top (Barrington & Brown, 2005). But comparing similar syllabuses internationally shows the current 4 unit course does *not* come out on top (Stacey et al., 1998).

A new 2-year 4 unit course is a possibility. There are a lot of people who want it. I accept that there might be some who won't. All views will be considered in the consultation process.

It's not just about being the best in the country. We should, with a large international student body thesedays, be expecting to be the best in the world. If that means bringing back stuff like determinants, adding new stuff like Number Theory and getting rid of stuff like probability, then so be it.

In the recommendations in the Stacey review on which the current syllabus changes will be based, it was recommended to maintain rigour and proofs and the US Math War has become infamous for ruining the US school system for maths for not maintaining it.

So although there is the possibility of improving the course, there is also the danger of it being dumbed down, as was HSC Physics.

If the 4 unit course is dumbed down instead of strengthened, maybe some schools will ditch the HSC altogether and do 100% IB, or Foundation programs (where uni's deal directly with schools to get students, circumventing the Board of Studies).

Many MORE students would do HSC Physics if it were made more rigorous again. So if one is concerned with student numbers, mediocrity simply will not do. Before they dumbed down Physics, most 4 unit students did HSC Physics. Now they won't touch it with a bargepole because it's such rubbish. And we now have the bizarre situation of having General Maths students doing HSC Physics. So HSC Physics has embraced mediocrity and mediocrity has embraced HSC Physics. Does it support the education system having a bunch of air-heads doing HSC Physics instead of the best? What type of students do we want at Australian universities? Bums-on-seats air-heads? I'd advise the best students to avoid such universities if that were the case. We should not be sentinels of mediocrity. We should embrace excellence. If the best schools send their best students to the best uni's based on these other assessments rather than the HSC, or do the same to HSC maths as they did to HSC physics, it would make the Board of Studies irrelevant. So it's in their interest to maintain high standards, or else students will find someone else who will.

The Brown & Barrington review shows that we have a lot to lose if we go the way other states have gone. We need to learn a lesson from the research not to go the way of other states, nor the US. These dangers have been well articulated in for example, Smith, 2004 and Donnelly, 2004.

That we have 5% doing 4 unit and 50% doing General maths is a clear indication of failure to teach maths properly across the state in junior years. If we improve on this we might get more students doing 4 unit. We now have a new syllabus for K-10. But really, I think the quality of teaching is what deperately need improving upon at these levels if ever we are to hope to increase the numbers of students doing the higher levels in senior years, and for that matter, university.

The IB is currently being taught in several schools in NSW, and many students in NSW have got excellent results in the IB.

I'm not about to become a sentinel of mediocrity any time soon. So I'll stick to crucibles of excellence thanks very much. If that means making 4 unit a 2-year course then so be it.

A lot of the mediocrity comes from the universities themselves which is why so many top-performing HSC (and IB) students go straight overseas for their tertiary studies and don't bother with Australian uni's at all. Improvements are currently done as K-10, then Stage 6, then university. But *motivation* for improvements should be that universities improve first, then Stage 6, then K-10, i.e., it is currently done in the wrong direction.

One of the recommendations in the Stacey review was to include technology in the new syllabus. The consultation process has begun for the new syllabus and MANSW have put up a technology survey on their website:

http://www.mansw.nsw.edu.au/whatsnew/2006-technology-survey.pdf

So if you don't want Graphics Calculators in the HSC, just fill out the survey and return it to MANSW. Would you also say teach LaTeX instead of Microsoft Equation Editor? I'm quite sick of seeing masses of maths teachers using Equation Editor. It's embarassing. If they had to actually *teach* LaTeX, they'd have to learn it first and the mathematical world would thereafter be a better place (at least in NSW).

If a teacher doesn't have depth of knowledge beyond the syllabus, then the syllabus is the ceiling. And for good kids, that's not good enough. The syllabus should be the floor, not the ceiling (Lane, 2006). So whatever changes happen to the syllabus, good teachers will still extend students beyond the syllabus. For example, $e^{i\theta}$, cubic and quartic formulae and third derivative method for inflection points could be taught regardless if they are not in the syllabus. In the 2002 HSC exam a question was asked on the Riemann Zeta function at 2 which could be easily extended to get $\zeta(2) = \frac{\pi^2}{6}$. If we ensure high standards we should include the proof of Fermat's Last Theorem (Wiles, 1995 and Breuil, et al., 2001), as it is also in the new 7-10 syllabus.

I'd also say to do this one which is equivalent to the Riemann Hypothesis (Lagarias, 2002) and can easily be verified on the calculator for small values of n:

For integers $n > 1$,

$\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{n} + e^{\frac{1}{1}+\frac{1}{2}+\frac{1}{3}+\cdots+\frac{1}{n}} \ln(\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{n}) >$ sum of divisors of n

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Taylors College,

May 29, 2006