Technical Torture Test

J. Hefferon
Mathematics, Saint Michael's College
Colchester VT
`ftpmaint@tug.ctan.org`

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1 Introduction

In 1985-86 the *Notices of the American Mathematical Society* ran a series by Richard Palais on using a computer to produce technical text.[1] This series was very influential at the time, although most of the content is now only of historical interest. However, part of that series reprinted for a wide audience of mathematicians the article *Technical Wordprocessors for the IBM PC and Compatibles: A report by the PC Technical Group of the IBM PC Users Group of the Boston Computer Society*.[2] This report concluded that "TEX systems are in a class by themselves. The TEX user has power and flexibility unmatched by any conventional word processor."

As with the larger series, most of this report is no longer relevant. However, the committee's selection of benchmarks remains wonderful: they include a wide range of difficult tasks in the production of technical material, and showcase what TEX-based systems can do.

This showcase has a particularly interesting property. In this document I have reproduced these benchmarks using LATEX, the most popular way to use a TEX system. I have used only facilities covered in the standard documentation: *LATEX: a Document Preparation System*, and *The LATEX Companion*, and *The LATEX Graphics Companion*. That is, I have avoided wizardry. So, this document shows what a person can accomplish using only reasonable effort.

Notes. (1) I have corrected several typos in the original benchmarks. (2) The eighth benchmark uses the word processors to draw two chemicals. I have altered that to include the drawings as made by an external program, which is how chemical illustrations would happen today. More information on that is in that section. (3) The source of this document is available.

[1] Mathematical Text Processing, *Notices of the Amer. Math. Soc*, vol. 33, no. 1, Jan. 1986, p. 3–7.

[2] Authors: Avram Tetewsky, Jack Pearson. TEX reviewers: A.G.W Cameron, Jack Pearson. Reprinted in *Notices of the Amer. Math. Soc*, vol. 33, no. 1, Jan. 1986, p. 8–37.

Benchmark 1: L. Tsang and J. A. Kong, *Journal of Applied Physics*, **51**(7), July 1980, page 3471, equation 110.

$$W^{3\beta}_{m_1 n_1 n_2}(p_1, p_2) = U^{3\beta}_{m_1 n_1}(p_1, p_2) + \int_0^\infty \frac{dp_3 p_3^2}{8\pi^3} \sum_n \sum_m \sum_{\alpha_2} \sum_{\beta_2} \sum_{n'} \sum_{n''} (-1)^m$$
$$\times \left(\frac{U^{33}_{m_1 n_1}(p_1, p_2)}{p_3^2 - k^2} \right) z_{3 m_1 n_1} h_n(p_3, p_2) \cdot a^{\alpha_{23}}_{mn(m_1 - m)n' n_2} a^{\beta_2 \beta}_{-mn(-m_1+m)n'' n_2} W^{\alpha_2 \beta_2}_{(m_1 - m)n' n''}(p_3, p_2) \quad (110)$$

Benchmark 2: Athanasios Papoulis, *Probability, Random Variables, and Stochastic Processes*, second edition, McGraw-Hill, 1984, page 17.

Unions and Intersections The *sum* or *union* of two sets $\mathcal{A}$ and $\mathcal{B}$ is a set whose elements are all elements of $\mathcal{A}$ or $\mathcal{B}$ or of both (Fig. 2-3). This set will be written in the form

$$\mathcal{A} + \mathcal{B} \qquad \text{or} \qquad \mathcal{A} \cup \mathcal{B}.$$

The above operation is commutative and associative:

$$\mathcal{A} + \mathcal{B} = \mathcal{B} + \mathcal{A} \qquad (\mathcal{A} + \mathcal{B}) + \mathcal{C} = \mathcal{A} + (\mathcal{B} + \mathcal{C}).$$

We note that, if $\mathcal{B} \subset \mathcal{A}$ then $\mathcal{A} + \mathcal{B} = \mathcal{A}$. From this it follows that

$$\mathcal{A} + \mathcal{A} = \mathcal{A} \qquad \mathcal{A} + \emptyset = \mathcal{A} \qquad \mathcal{J} + \mathcal{A} = \mathcal{J}.$$

The *product* or *intersection* of two sets $\mathcal{A}$ and $\mathcal{B}$ is a set consisting of all elements that are common to the two sets $\mathcal{A}$ and $\mathcal{B}$ (Fig. 2-3). This set is written in the form

$$\mathcal{A}\mathcal{B} \qquad \text{or} \qquad \mathcal{A} \cap \mathcal{B}.$$

Benchmark 3: Richard P. Feynman, *The Feynman Lectures on Physics*, Addison-Wesley Publishing Co., 1965, Vol. 3, page 20-12, Table 20-1.

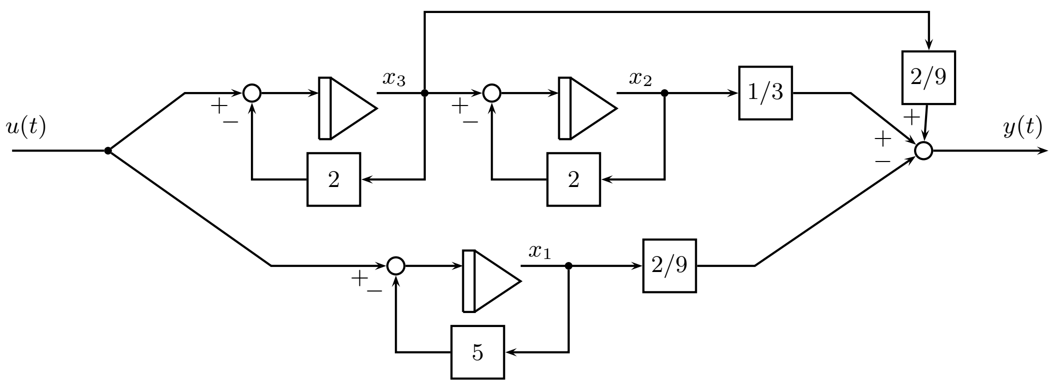
Table 1: **20-1**

Physical Quantity	Operator	Coordinate Form
Energy	$\hat{H}$	$\hat{\mathcal{H}} = -\frac{\hbar^2}{2m}\nabla^2 + V(r)$
Position	$\hat{x}$	x
	$\hat{y}$	y
	$\hat{z}$	z
Momentum	$\hat{p}_x$	$\hat{\mathcal{P}}_x = \frac{\hbar}{i}\frac{\partial}{\partial x}$
	$\hat{p}_y$	$\hat{\mathcal{P}}_y = \frac{\hbar}{i}\frac{\partial}{\partial y}$
	$\hat{p}_z$	$\hat{\mathcal{P}}_z = \frac{\hbar}{i}\frac{\partial}{\partial z}$

In this list, we have introduced the symbol $\mathcal{P}_x$ for the algebraic operator $(\hbar/i)\partial/\partial x$:

$$\mathcal{P}_x = \frac{\hbar}{i}\frac{\partial}{\partial x}.$$

Benchmark 4: William L. Brigan, *Modern Control Theory*, QPI Quantum Press Inc., Prentice Hall, 1984, page 240, Figure 9.11.



From Fig. 9.11,

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -5 & 0 & 0 \\ 0 & -2 & 1 \\ 0 & 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} u \qquad \text{and} \qquad y = \begin{bmatrix} -2/9 & 1/3 & 2/9 \end{bmatrix} x$$

Benchmark 5: Marsden, J.E., *Elementary Classical Analysis*, W.H. Freeman and Co., 1974, page 234, proof of Theorem 2.

Proof. Define the function $G\colon A \subset \boldsymbol{R}^n \times \boldsymbol{R}^m \to \boldsymbol{R}^n \times \boldsymbol{R}^m$ by $G(x, y) = (x, F(x, y))$. Since F is of class C^p and the identity matrix is of class C^∞, it follows that G is of class C^p. The matrix of partial derivatives of G (Jacobean matrix) is

$$\begin{pmatrix} 1 & 0 & \dots & 0 & 0 & \dots & 0 \\ 0 & 1 & & & & & \\ \vdots & & \ddots & \vdots & \vdots & & \vdots \\ 0 & & \dots & 1 & 0 & \dots & 0 \\ \dfrac{\partial F_1}{\partial x_1} & & \dots & \dfrac{\partial F_1}{\partial x_n} & \dfrac{\partial F_1}{\partial y_1} & \dots & \dfrac{\partial F_1}{\partial y_m} \\ \vdots & & \ddots & \vdots & \vdots & & \vdots \\ \dfrac{\partial F_m}{\partial x_1} & & \dots & \dfrac{\partial F_m}{\partial x_n} & \dfrac{\partial F_m}{\partial y_1} & \dots & \dfrac{\partial F_m}{\partial y_m} \end{pmatrix}$$

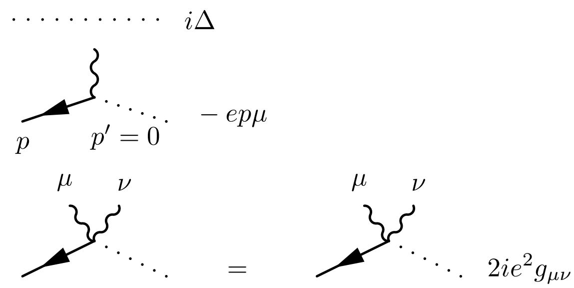
□

Benchmark 6: Henry, Allen F., *Nuclear Reactor Analysis*, MIT Press, Cambridge, Mass., 1982, page 495, subequations 4 and 5.

$$iB_r[\tilde{a}^n_{kl}] \equiv \frac{1}{2}(h_{n-1} + h_n)\int_0^R 2\pi r\, dr[\rho^{n*}_k(r)]\frac{d}{dr}[\Psi^n_l(r)],$$

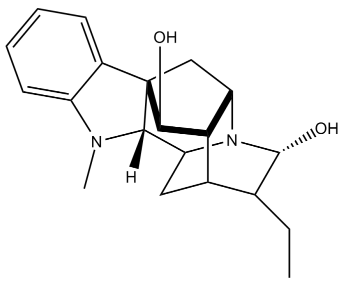
$$[D^n_{r,kl}]^{-1} \equiv \int_0^R 2\pi r\, dr \int_{z_n - \frac{1}{2}h_n - 1}^{z_n + \frac{1}{2}h_n} [\rho^{n^*}_k(r)][D^{-1}(r,z)][\rho^n_l(r)],$$

Benchmark 7: Guendelman and Radulovic, "Infrared Divergence in Three-Dimensional Gauge Theories" *Journal of the American Physical Society*, **30**, No 6, 15 Sept 1984, page 1347, Figure 13.

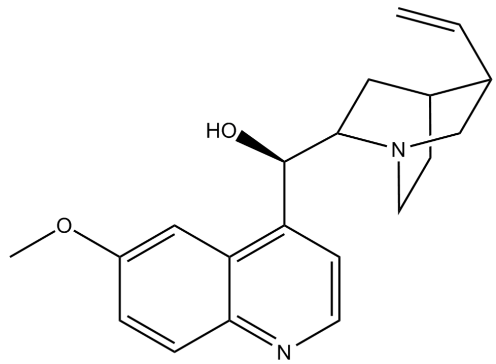


Benchmark 8: Hendrickson, Cram, and Hammond, *Organic Chemistry*, McGraw-Hill, 1970, page 1078, Figure 27-6, Ajmaline and Quinine.

In the original report, this benchmark uses the technical word processors to draw the structure for these two chemicals. Dr B Findley of the Saint Michael's College Chemistry Department has explained to me that the benchmark's diagrams are not up to current professional standards. He graciously provided me with `.png` graphics produced with *ChemDraw*. I used the `convert` program to make them `.eps` files and have included them as graphics. This illustrates how a modern TEX system integrates with other tools in a professional workflow.



Ajmaline



Quinine

Benchmark 9: The following expressions.

$$f_{\underline{Z}}(\underline{Z}) \qquad f_{\underline{y}}(\underline{y}) \cdot e^{\alpha^{\beta}}$$

Benchmark 10: Place benchmark examples 1 through 9 in one file. See if pagination works and if the system has enough memory or stack to do the work.

This document witnesses the success that TeX has with this benchmark.