LETTERS

FIRST LAW OF THERMODYNAMICS

One of the main difficulties in teaching the first law of thermodynamics is getting students to realize that heat (Q) and work (W) are interactions, in contrast to internal energy (U) which is a property of the material system considered.

It is somewhat surprising therefore to find that the formulation which now appears in some A-level syllabuses (e.g. the new, 1977, University of London A-level physics syllabus) and which is followed by a number of recently published school textbooks, viz

$$\Delta Q = \Delta U + \Delta W \qquad (1)$$

is contrary to the normally accepted mode of presentation. The first law is usually stated

$$Q = \Delta U + W. \qquad (2)$$

Statement (1) implies

$$(Q_2 - Q_1) = (U_2 - U_1) + (W_2 - W_1).$$

This could lead a student to suppose that since U_1, U_2 are the energies for two particular states of the system, then Q_1, Q_2 and W_1, W_2 are also properties associated with these states. *R E M Shaw*

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HOW SWINGERS DO IT—WITHOUT CALCULUS

The energy which a swing rider may impart to a simple swing system of which he is a part, during half a period of swinging oscillation, has been calculated as

$$W = 12\, mga\, \theta_0^2/\pi$$

by R V Hesketh (*Physics Education* 1975 **10** 367–9), whose method requires an integration and involves terms which, after being recognized as spurious, are correctly ignored.

I would like to show a noncalculus solution which, in addition to being simpler, avoids the spurious terms. In contrast to the prior treatment, which considered a sinusoidal variation in the distance of the centre of mass from the ideal pivot, an impulsive rise through a distance $2a$ is considered to occur near the plumb position followed by a radial reversal of this $2a$ displacement when the swing is at θ_0, its position of greatest angular displacement from the plumb position.

The exchange of steady-state kinetic energy for potential energy gives $mv^2/2 = mgH$ for the swing of average length l_0; so the centripetal force is $mv^2/l_0 = 2mgH/l_0$, which the swinger must furnish when near the plumb position (in addition to his weight) in raising m through the vertical distance $2a$. The corresponding work is $W' = 2a2mgH/l_0$.

From $(l_0 - H)/l_0 \equiv \cos\theta_0$ and the assumption used by Hesketh that $\theta_0^2 \ll 1$, we get $1 - H/l_0 \simeq 1 - \theta_0^2/2$, or $2H/l_0 = \theta_0^2$. On eliminating H/l_0, we get $W' = 2mga\theta_0^2$. Because the centripetal force is zero when the extension by $2a$ occurs, none of this energy is regained by the swinger.

The swinger raises his weight the distance $2a$ *directly* against gravity but, when the $2a$ extension occurs, only the component $2a \cos\theta_0$ is parallel to gravity. So the further net energy required by the swinger is

$$W'' = mg2a - mg2a\cos\theta_0 \simeq mga\theta_0^2.$$

The sum of these energy inputs is

$$W' + W'' = 3mga\theta_0^2 \equiv (3\pi)(mga\theta_0^2/\pi),$$

which would be identical to the final result of Hesketh except that $3\pi \neq 12$. *Frank E Rose*

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BOILING WATER

The A-level question about boiling water ('Why is this a bad question?' *Physics Education* 1975 **10** 266) seems to be a bad one only because it requires the examinee to think about the question, rather than quote a book. Thus it will not be easy to mark the answer fairly.

If the examinee can envisage boiling being maintained by means other than the application of heat, e.g. by a number of Maxwell demons armed with the appropriate size of billiard cue, he should be awarded a bonus. *M F Culpin*

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In addition to the reason given, there is the further one that hot water in a closed vessel can be made to boil by pouring cold water on it. *R M Helsdon*

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THE DOPPLER EFFECT

The editorial theme for the July issue of *Physics Education* (1975 **10** 337) and the subsequent articles concerning the relevance of mathematics to physics caused me to look critically at R M Helsdon's derivation of the demon Doppler relation (*Physics Education* 1975 **10** 395).

The objective of the exercise would appear to be the speedy production of the literal algebraic relation without too much reference to 'reality' and with a rather confusing assumption. However worthy such an objective may be for examination purposes, many