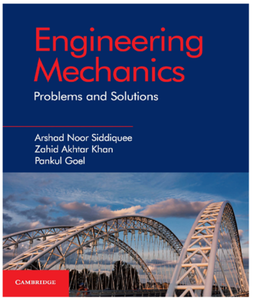

Engineering Mechanics: Problems and Solutions

A. N. Siddiquee *et al.*

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This elementary text has been compiled by two fully fledged Professors aided by an Associate Professor with 20 years' teaching experience. All three authors claim to be actively engaged in the study of a wide range of practical engineering topics and the blurb suggests that the optimisation of design is a common interest of all three. The authors' thoughts on how best to teach the subject are made known in the Preface and are most encouraging. The authors write:

> *'the learner needs to be presented cases similar to those encountered in real engineering problems and situations'.*

The Introduction, Chapter 1, reveals that a complete study of the subject entails statics, dynamics and hydrostatics, but only statics and dynamics are considered here. See Figure 1.1 for further clarification. The need for a coherent system of units is adequately explained, albeit the need for dimensional homogeneity is not discussed. The laws of motion, gravitation and forces are noted in Section 1.7. But Section 1.5 is of little practical value, whilst Section 1.8 on vector algebra fills pages 12–30, yet plays no further part in the text.

Bearing in mind this text is primarily a collection of worked examples, over 300 in all, with approximately 150 problems for the student to solve, the reviewer spent a while checking method, algebra and accuracy of a few solutions selected at random. All but one example tested proved easy to follow and numerically correct, but not so many of the 500 plus so-called rich illustrations, far too many of which are riddled with easily spotted Geometrical/Dimensional errors, mainly in Chapters 2–6. There are, in fact, at least 30 such errors in the first 15 pages of Chapter 2. There are, for example, eight instances where the angle drawn does not correspond with the numerical angle stated. Five supposedly equal 72° sectors (Fig. 2.3(a)) range from 88° (large) to 68° (small). Figure 2.14(c), 60° keyed in 50° drawn. Figure 2.17(a), 60° keyed in 30° drawn. Other draughting errors include Example 2.1 which shows three triangles, the proportion of which does not conform to the numerical rations stated. Figure 2.22(b) shows two base angles 60°/60°, indicating an isosceles triangle, yet sides AC/AD are not equal. The number of times normals is drawn which are not at 90° (normal) to the line/curve to which they apply is mind boggling and highly misleading.

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The CAD operators understanding of shape is no better. Figure 2.1 for instance shows a squashed six-sided figure, referred to in the text as a regular hexagon, which as drawn it is not. Figure 3.2 shows a cricket stump with an aspect ratio of approximately five which looks more like the blade of a cricket bat than a cricket stump, which has an aspect ratio more like 20. Figure 3.3 shows a crude representation of plier grips, so strong they can crush a hexagonal engineering nut by hand, hardly a realistic engineering example.

'Two-Dimensional Concurrent Forces Systems' – Chapter 2 – provides examples of how forces, converging on a point, may be resolved into mutually perpendicular *x, y* components and how equilibrium may be satisfied. The use of free body diagrams, Section 2.4, is superficial and inadequate, but Section 2.6 on Lame's Theorem is useful.

'Two-Dimensional Non-Concurrent Force Systems' – Chapter 3 – defines moment, couple, moment of couple and equations of equilibrium including Varignon's theorem. Numerous observations relating to beams are included but apart from that the treatment is no more taxing than A Level Applied Maths.

'Friction' and 'Applications of Friction' – Chapters 4 and 5 contain a motley of examples which demonstrate the application of Coulomb's Law of Friction. So much space is consumed by problems involving incline planes, wedge block interactions and ladders propped safely and/or unsafely against vertical walls, there is no space left to consider how friction affects journal and collar bearings (so common place) in many machines. The authors also make a hash of explaining angle of repose. The authors write: 'As dictionary defines repose means a body to remain in sleep'. The reviewer suggests that reference to a pile of sand or the slope of a railway embankment would have provided a far more apt and explicit explanation. The authors dealing with screw threads also gets off to a dodgy start. Figure 5.13 occupies two thirds of a page and shows a left hand helical thread, when (as almost everyone knows) right handed threads are almost exclusively used in mechanical engineering practice. Figure 5.14 shows what the authors may well regard as an optimised screw jack, is nothing of the sort. The first absurdity is the sugar cube load marked *W* perched on top of a rotating screw, whilst a visual estimate of frontal areas indicates the volume of a hollow base is likely to be at least 100 times that of the load to be lifted. Moreover, the cross section of screw and base (hence stresses) are likewise incompatible. The authors clearly have no idea of what an industrial screw jack, capable of lifting 100 tons or more, actually looks like. In fairness to the authors, it is right to point out that the efficiency of a screw and nut (but not a screw jack) is adequately explained several times over, see pages 211–216. The remainder of the chapter considers the effect of tight side/slack side pulley belt tensions and various crude band brake actions are also explained.

Chapter 6 'Analysis of Trusses' covers the method of Joints, the method of Sections and includes an equation for deciding if one is dealing with a mechanism (word not used in text), a statically determinate or a singly redundant structure. There are, however, several important points the authors fail to mention. First, the equation quoted by the

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authors is not universal. For example, the equation correctly classifies the two bay simply supported truss, without diagonals, Figure 6.2 as structurally deficient and if a single diagonal member be inserted in bays 1 and 2, correctly predicts that the new structure is statically determinate. But, what if two opposing diagonals be fitted in bay 1, bay 2 being left without a diagonal? Then bay 1 would be statically indeterminate and bay 2 would remain structurally deficient; the reviewer's point being the equation would incorrectly classify the two-bay structure as stable. Suffice to add a more refined law is required if it is to ring true every time. Numerous pin jointed triangulated trusses are presented, Figure 6.23 being typical of a truss of modest span, yet here again anyone who is able to read a simple engineering diagram will realise that although the topology (inter connection of members) is correct, the structure as drawn does not comply with the dimensions given. No architect, structural engineer or town hall officer (charged with giving planning approval) would accept such a deceptive misrepresentation shape. (1) The horizontal position of the shoulder loads is not given; (2) the position of nodes L and N are not given; (3) the arrow head intended to define position of node F falls way short of F (approximately one foot in real terms); (4) the text does not specify that AC is half AE and Figure 6.23 places node C in quite the wrong position; whilst the supplementary Figure 6.23(a) maintains the 45° slope, giving a completely false impression of ridge height ME.

The authors' mastery of A level mathematics is demonstrated in Chapters 7 and 8, where 57 pages are devoted to the calculation of centroids. Another 58 pages are devoted to the calculation of moments of inertia. Parallel axis and perpendicular axis (polar) theorems are clearly explained. 'Shear Force and Bending Moment Diagrams' – Chapter 9 – is highly repetitive but far more likely to prove of practical use than many of the cross-sections considered in Chapters 7 and 8.

The switch from Statics to Dynamics occurs with the introduction of Kinematics of a particle in Chapters 10 and 11, where Rectilinear and Curvilinear cases are considered. The authors choose to define the relationships between displacement, time, velocity and acceleration using elementary differential and/or integral calculus, 10 pages before the more easily understood equations connecting u, v, a, t and s are made known to the less mathematically able. The authors' treatment of curvilinear motion is largely limited to the vertical plane – NB Examples 11.1, 2 and 3 are entirely algebraic. There are, however, 16 worked examples relating to the flight of projectiles. Curved path motion is also discussed in Chapter 15.

Whilst the authors' mathematical explanation of centripetal (normal) acceleration is sound, the word centripetal is not listed in the Index and the reviewer has found only one instance of its use, see page 534. No mention of its counterpart predicted by Newton's Third Law of Motion is to be found. How a bike rider is able to circle the wall of death is not explained. Why the outer rail of curved railway tracks is higher than the rail on the inside of the curve is not explained. How centrifugal force dictates (with temperature) the design of turbine blades is not considered.

'Kinetics of Particles' – Chapter 12 – begins with a repeat of Newton's Third Law of Motion (first made known in Section 1.7, page 8). The use is made of D'Alembert's Principle to evaluate the effect of inertia when hauling heavy weights.

'Work and Energy' – Chapter 13 – provides definitions of work, energy and power, culminating with the Conservation of Energy Principle, but pays far too much attention to the very basic problem of shifting virtual blocks of matter from here to there. The trade off between Potential and Kinetic energy is discussed and a few worked examples provided, but nothing of practical value is said about the through-put of work/energy/power. The authors make no mention of velocity ratio (a design decision) or mechanical advantage (dependent on friction and known only via experimental test), hence no mention of the law to a machine. No formal mention of gearing, still less a chance of finding a pinion or spur gear wheel, in any of the examples.

'Impulse and Momentum' – Chapter 14 – introduces the Principle of Conservation of Momentum which uses Newton's Second Law in a slightly different context. The coefficient of restitution is defined and billiard/snooker shots explained. Example 14.1 considers the input of a pile driver and Example 14.17 follows the impact of an 18,000kg bus on an autorickshaw of mass 800kg, the essence of which is to show there is a loss of energy.

'Kinematics of Rigid Bodies' – Chapter 15 – is mainly but not entirely concerned with rotary motion. The Instantaneous Centre Concept is introduced and more examples of slipping ladders are present. The equation linking linear and angular velocity is clearly explained, although simple harmonic motion (SHM) is not discussed. The relationship among Linear, Normal and Angular acceleration is shown to depend on mathematical differentiation and integration (tied to a constant of integration C the removal of which is explained on pages 664 and 665). A further point to be noted is the authors' use of the word 'normal/radial' (force/acceleration) instead of centripetal force/ acceleration as is more common in other texts.

'Kinetics of Rigid Bodies' – Chapter 16 – reviews moment of momentum, torque and angular momentum with the conservation of energy principle. Twenty-one worked examples are provided (mainly of a contrived mathematical nature), Example 16.8, which relates to a rolling mill, being the sole exception.

Nevertheless, the solutions are mathematically sound and from Section 16.3 cover various situations in which kinetic energy, in both translation and rotation, is involved.

'Virtual Work' – Chapter 17 – offers the reader an alternative way of solving many of the 'static' problems previously considered, namely: ladders propped against walls; blocks sliding down incline planes; triangulated structures; pulley problems; a scissor jack and beams. With regard to the scissor jack, in Example 17.16, the reviewer notes that turning the single threaded screw shown in Figure 17.19 moves both nodes *C* and *D* to the right or to the left, thereby destabilising as opposed to lifting the load. A single threaded screw works fine on a '*Y* form' jack, supplied with private cars but a 'diamond' scissor jack requires a 'turnbuckle' screw with right hand thread one end and a left hand thread at the other end.

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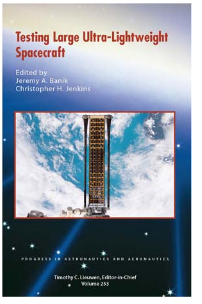
The reviewer now has two points to make: The reader should note the Principle of Virtual Work enables the Smiths lazy tongs, Example 17.7, to be solved in two lines. This statement of fact prompts the reviewer to suggest that the reader draw a free body diagram (see Section 2.4) and verifies the result obtained by the author. But more important the reader should ask the question: can the Smiths purchase be further enhanced by addition of further stages? This is the type of question the authors should be asking.

Although this book presents over 300 worked examples, which a few students may find useful, there are far too many inaccurate line diagrams (which should have been spotted and corrected prior to publication) to make this text a serious contender for widespread use. The general level of text is narrow, repetitive and barely stretches the mind beyond A Level applied maths. There are in fact so many examples relating to incline planes, ladders and hypothetical pulley block configurations that a cynic might conclude the authors are more interested in calculating forces relating to apparatus dating back to the pyramid/cathedral building age, than in addressing basic engineering problems of contemporary relevance and interest.

The authors' early thoughts on how best to teach the subject have not been fulfilled.

Peter C. Gasson, CEng, MIMechE, FRAeS



Testing Large Ultra-Lightweight Spacecraft. Progress in Aeronautics and Astronautics series – Vol 253

Edited by J. A. Banik and C. H. Jenkins

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Testing Large Ultra-Lightweight Spacecraft is the third book from the co-editor C.H.M. Jenkins in the AIAA Progress in Aeronautics and Astronautics series on the topic of large ultra-lightweight spacecraft (LULS) structures, otherwise known as gossamer structures. It follows *Gossamer Spacecraft: Membrane and Inflatable Structures Technology for*

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