Your solution

You should write a brief account of your solution to this problem. Question 1 of this TMA, and the drug therapy and skid marks reports in *Unit M*, all provide useful examples of what is required. We suggest, however, that for definiteness you should base your solution on the summary of Section 4 of *Unit M*, and that in your answer you should make sure you deal with the following points.

(i) *Specify the real problem*

Formulate in your own words clear statements of the general and particular problems to be solved. [4]

(ii) *Set up a model*

Define precisely all of the parameters and variables you use, select symbols to represent them, and give appropriate units. (For example: 'd is the distance between successive speed humps, in metres'.) [5]

Carefully state the simplifying assumptions which you have made in formulating your model. (For example: 'It is assumed that while a car is speeding up after crossing a speed hump, its acceleration is constant.') [5]

For each of the two phases of a car's motion, while it is accelerating and while it is braking, write down a formula relating the maximum speed the car attains to the distance it covers, using the symbols you have defined previously. [4]

(iii) *Formulate the mathematical problem*

Explain briefly how the two formulas you wrote down in the previous part may be used to find a relationship between the distance between the humps and a car's maximum speed. [2]

(iv) *Solve the mathematical problem*

Obtain an equation giving the separation of the humps in terms of the maximum speed attainable between them. $S = \frac{1}{2} t_a V_m + \frac{1}{2} t_d V_m = \frac{1}{2} V_m (t_a + t_d)$ [6]

(v) *Interpret the solution*

(a) *Qualitative interpretation*

One might guess that halving the speed limit would necessitate halving the distance between the humps – but is this so? By sketching a graph of the separation of the humps against the maximum speed (and without introducing any specific values for the parameters), discuss how the spacing of the speed humps depends *qualitatively* on the speed limit imposed, all other parameters being kept constant. [4]

State whether the separation of the humps will increase or decrease, according to the model in part (iv), as a result of the following changes, assuming in each case that all the other parameters remain unchanged.

- The speed over a hump decreases.
- The acceleration between humps increases.

Give reasons for your answers, and state whether or not the behaviour is what you would expect from common sense. [4]

(b) *Quantitative solution*

Now use your model from part (iv) to obtain a *quantitative* answer to the initial question: that is, to suggest how far apart the speed humps should be positioned along the road through Millbrook, and how many are needed. You should clearly state the data values you decide upon, with reasons for your choices. Your final answer should be in the form of instructions on the siting of the speed humps along the road which could be understood by a non-mathematician. You might like to support your answer with a sketch showing the positioning of the humps along the road through Millbrook. [10]