



## Open mathematics

### *Journeys as Graphs*

#### **Judy Ekins**

I went to Bridgnorth and boarded a train for Kidderminster with Keith Shaw, who has responsibility for timetabling the service. The first stop was to be at Hampton Loade, one of several stations and potential passing places on the way. Like all good railway supervisors, Keith is armed with a stopwatch.

#### **Keith Shaw**

Ah, nine o'clock, right on time.

#### **Judy Ekins**

Slowly but surely, the train gets up steam. But its departure time is being noted for a reason.

Could you tell us what you're doing today?

#### **Keith Shaw**

Well, we're just checking the times of the trains in order to compose a timetable – we've just left Bridgnorth now pretty well on time. We've had some difficulty starting, as you will have noticed, but that's something that maybe we have to take into account in the timetable.

#### **Judy Ekins**

Do you have problems with trains being late?

#### **Keith Shaw**

No, not too bad. On the other hand, it is important that we don't just sit back and look at the timetable and say, well, that's it forever.

#### **Judy Ekins**

So, let's look at some of the local landmarks and key places that affect the journey time. The train has reached a place called Sterns, just over half way to Hampton Loade, where there is a danger of the line slipping into the river, and so there's a speed restriction, or 'slack', of five miles per hour.

#### **Keith Shaw**

It's 9.15, we've just passed the slack at Sterns, and as this is only a one-coach train, of course, it doesn't take us long to pass it, but if you've got eight or nine coaches on, the whole of the train would have to pass the short section – I'll just make a note of that.

#### **Judy Ekins**

The particular train on which we're travelling only needs to have one coach, because it's the early morning taxi for railway personnel.

#### **Keith Shaw**

Right, we're approaching Hampton Loade now, and at Hampton Loade there's a very interesting ferry, and there's a ferry across the river which has no power, no motive power. It's driven by the current of the river, and it's two very elderly ladies operate it; if you want to cross you go and push a button on a pole, and they come out of their house and get in the boat, and it's anchored to a wire which runs across the river, and by manipulating the rudder, they can use the current to drive the boat across and back. It's quite fun. And occasionally when I see them at Hampton Loade, I use the ferry, park the car on the other side of the river and come across it – which is quite nice. It's quite a nice feature.

Just approaching Hampton Loade station now, so we need to check the time. Just 9.20.

**Judy Ekins**

So, that's the journey as far as Hampton Loade, a distance of seven point two kilometres, and we arrived at 9.20.

A useful way to represent a journey is to draw a position–time graph, marking positions on the vertical axis, with BN for Bridgnorth and HL for Hampton Loade. The horizontal time axis is divided into equal time intervals, starting at nine o'clock, when the journey began, up to 9.20, when we reached Hampton Loade.

The graph of the trip from Bridgnorth to Hampton Loade looks like this. Up until nine o'clock, the train was stationary at Bridgnorth, and so the graph is horizontal. As it speeded up, the graph gets steeper. At about six minutes past nine, the train had settled to a constant speed, for a period of five to six minutes. But then it slowed down to enter the cutting at Sterns, where there is a speed limit. Let's mark the position of Sterns on the vertical axis. At 9.16, once the train had passed through Sterns, the graph gets steeper again, as the train speeded up, until it finally slowed down as it approached Hampton Loade station, where it stopped at 9.20.

The next part of the journey took us beyond Hampton Loade to Highley Station, along another three point three kilometres of single-track railway. There were a number of factors which affected our speed.

So, where are we now, Keith?

**Keith Shaw**

Well, we're, we've just past Alveley sidings, we're approaching Highley; we've come over Highley Bank, which is quite a steep gradient, and it's reverse curves, that's curves in one direction and then the other, which makes for increased friction, which makes it more difficult for the driver, and so we should be approaching Highley soon. Of course, in the opposite direction, the gradient works in the driver's favour, so he doesn't, it's important that he keeps to the speed restriction in that direction as well. Slowing now for Highley, I'll check the time and – 9.27.

**Judy Ekins**

After Highley, there's Arley Station, a further three point five kilometres up the line – which we reached at 9.36.

One kilometre beyond Arley, the line crosses over to the other bank of the river.

**Keith Shaw**

Well, that's 9.40. We're just crossing Victoria Bridge, which when it was built in 1861 was the largest single-span iron structure ever built at that time, by a firm called John Fowler, and it's 200 feet, single span. Now on the faster section of the line – it doesn't have so many slacks on as the earlier part, and also of course by now the engine's warmed up and things are running much more as they should be.

**Judy Ekins**

There's one more stop before Kidderminster, and that's in the town of Bewdley. To get to Bewdley station we've travelled a total of 20 kilometres from Bridgnorth and arrived at 9.50. The next landmark was the tunnel.

**Keith Shaw**

We're just approaching Bewdley Tunnel now, this is another timing point – 9.56.

Engines of course whistle when they go in, to warn anyone who's inside that there's a train coming, because there's no way you – maintenance staff might be on the ground in the tunnel or doing some work, and they need to know to get out of the way. There are little niches in the side of the tunnel in which you can stand if a train comes by, so – but they still need to be warned.

**Judy Ekins**

The tunnel was the last timing Keith made before we reached our final destination, Kidderminster town.

On the outskirts of Kidderminster the single track becomes double again. Our final arrival time: 10.10.