STEP II, 2007, Q11 MS

Q11 In a similar sort of way to Q9, this is just a reasonably standard projectiles question dressed up a bit, and the vector set-up should help you work in the third-dimension quite naturally. The given answer in (i) should help confirm that you're doing the right thing to begin with (or not!). Completing the square, or differentiating, will give the value of t when OP is a minimum, and this should then turn out to be the same instant/position as can be found in part (ii) by differentiating the vertical ($\mathbf{k}$ –) component of the displacement vector.

Part (iii) can be done in a couple of ways: one is very lengthy, pressing on with the vector formulation for as long as possible, but the intended approach is to work with distance and time as scalars on the assumption that the bullet moves in a straight line.

Answers: (i) $\underline{\mathbf{r}} = \left(50 - 5t\sqrt{5}\right)\mathbf{i} + \left(5t\sqrt{15}\right)\mathbf{j} + \left(5t\sqrt{5} - 5t^2\right)\mathbf{k}$;

$\underline{\mathbf{p}} = \frac{75}{2}\mathbf{i} + \frac{25\sqrt{3}}{2}\mathbf{j} + \frac{25}{4}\mathbf{k}$; $(0)60^\circ$.