

## STEP II, 2011, Q11

- 11 The maximum power that can be developed by the engine of train A, of mass  $m$ , when travelling at speed  $v$  is  $Pv^{3/2}$ , where  $P$  is a constant. The maximum power that can be developed by the engine of train B, of mass  $2m$ , when travelling at speed  $v$  is  $2Pv^{3/2}$ . For both A and B resistance to motion is equal to  $kv$ , where  $k$  is a constant.

For  $t \leq 0$ , the engines are crawling along at very low equal speeds. At  $t = 0$ , both drivers switch on full power and at time  $t$  the speeds of A and B are  $v_A$  and  $v_B$ , respectively.

- (i) Show that

$$v_A = \frac{P^2 (1 - e^{-kt/2m})^2}{k^2}$$

and write down the corresponding result for  $v_B$ .

- (ii) Find  $v_A$  and  $v_B$  when  $9v_A = 4v_B$ . [You may find the substitution  $v_A = u^2$  useful.]
- (iii) Both engines are switched off when  $9v_A = 4v_B$ . Show that thereafter  $k^2v_B^2 = 4P^2v_A$ .



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