

### Problem 292A

Many versions of the Boeing 747 (weight  $3 \times 10^6 \text{ kg}$ ) are powered by four Pratt and Whitney JT9D-7A turbofan engines, each of which can produce a thrust at sea-level of approximately  $200,000 \text{ kg m/s}^2$  (neglect the fact that this may change with forward speed). During take-off with flaps partially down the lift coefficient based on a wing planform area of  $550 \text{ m}^2$  is 1.6 and the lift/drag ratio is 22. Assume an air density of  $1.2 \text{ kg/m}^3$ . Calculate:

1. The take-off speed.
2. The runway length from a standing start to take-off and the acceleration during this time assuming the drag can be neglected.
3. The actual acceleration at take-off when the drag is included in the calculation.