M1. (a) the distance travelled under the braking force

(b) the reaction time will increase

increasing the thinking distance (and so increasing stopping distance)

(increases stopping distance is insufficient)

(c) No, because although when the speed increases the thinking distance increases by the same factor the braking distance does not.

eg

increasing from 10 m / s to 20 m / s increases thinking distance from 6 m to 12 m but the braking distance increases from 6 m to 24 m

(d) If the sled accelerates the value for the constant of friction will be wrong.

(e) only a (the horizontal) component of the force would be pulling the sled forward

the vertical component of the force (effectively) lifts the sled reducing the force of the surface on the sled

(f) \(-u^2 = 2 \times -7.2 \times 22\)

award this mark even with 0^2 and / or the negative sign missing
$u = 17.7(99)$

allow 18 with no working shown for 3 marks

allow 17.7(99) then incorrectly rounded to 17 for 2 marks
M2. (a) 4 (m/s)

1 mark for correct transformation of either equation
1 mark for correct substitution with or without transformation
1 mark for correct use of 0.6N
max score of 2 if answer is incorrect

(b) greater change in momentum

or greater mass of air (each second)

or increase in velocity of air
accept speed for velocity

force upwards increased
lift force is increased
do not accept upthrust

or force up greater than force down
accept weight for force down

(c) • increase the time to stop

• decrease rate of change in momentum or same momentum change
accept reduced deceleration/acceleration

• reducing the force on the toy
do not accept answers in terms of the impact/force being absorbed

do not accept answers in terms of energy transfer
do not credit impact is reduced
M3.  (a) idea that balanced by friction force* / pushing force equals friction force (*note “balanced” by unspecified force)
   or
   specification of relevant force but no reference to balancing in both 1(a) and 1(b) gains 1 mark overall
   for 1 mark
   
(b) balanced by upwards force of table*
    for 1 mark
    
(c) makes it (slightly) warm / hot
    or
    wears it away (slightly) / damages surface
    for 1 mark
    
[3]
M4. (a) (i) a single force that has the same effect as all the forces combined
   accept all the forces added / the sum of the forces / overall force
   1

   (ii) constant speed (in a straight line)
        do not accept stationary
        or constant velocity
        1

   (b) 3
        allow 1 mark for correct substitution into transformed equation
        accept answer 0.003 gains 1 mark
        answer = 0.75 gains 1 mark
        2

        m/s²
        1

   (c) as speed increases air resistance increases
        accept drag / friction for air resistance
        1

        reducing the resultant force
        1 [7]
M5. (a) the forces are equal in size and act in opposite directions

(b) (i) forwards / to the right / in the direction of the 300 N force
   *answers in either order*

   accelerating

(ii) constant velocity to the right

(iii) resultant force is zero
   *accept forces are equal / balanced*

   so boat continues in the same direction at the same speed

(iv) parallelogram or triangle is correctly drawn with resultant

   value of resultant in the range 545 N – 595 N
   *parallelogram drawn without resultant gains 1 mark*
   *If no triangle or parallelogram drawn:*
   *drawn resultant line is between the two 300 N forces gains 1 mark*
   *drawn resultant line is between and longer than the two 300 N forces gains 2 marks*
M6. (a) more streamlined

accept decrease surface area

air resistance is smaller (for same speed)
accept drag for air resistance
friction is insufficient

so reaches a higher speed (before resultant force is 0)
ignore reference to mass

(b) (i) 1.7

allow 1 mark for correct method, ie \( \frac{5}{3} \)
or allow 1 mark for an answer with more than 2 sig figs that rounds to 1.7
or allow 1 mark for an answer of 17

(ii) 7.5

allow 1 mark for correct use of graph, eg \( \frac{1}{2} \times 5 \times 3 \)

(iii) air (resistance)

accept wind (resistance)
drag is insufficient
friction is insufficient