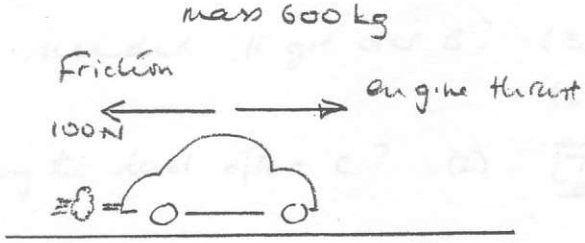
Test ~ Linear Dynamics – Force + Momentum + Motion (1) A Physics

- take $g = 10\ m/s^2$
- assume air resistance is zero unless told otherwise

1. (a) Give Newton's 3 laws of Motion – words, no equations (3)

(b) Give the 2 formulae that come from Newton's 2nd law; explain all symbols & give all units (2 × 3)

2. The car accelerates steadily from rest to 20 m/s in 15 sec, and then maintains that steady speed.



(a) What engine thrust is needed to produce that acceleration? (3)

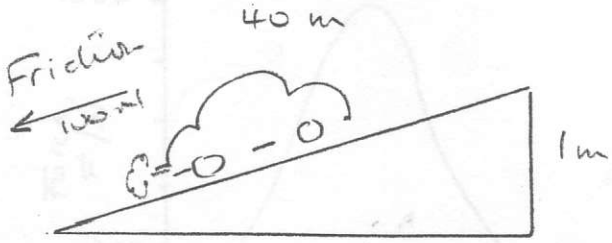
(b) What is the engine power at 6.0 sec after starting off? (4)

(c) What is the engine thrust needed to maintain a steady 20 m/s? (1)

(d) What is the rate of working against friction? (2)

(e) If the car engine is 40% efficient, at what rate is chemical energy (petrol) consumed? where does the wasted energy go? (3)

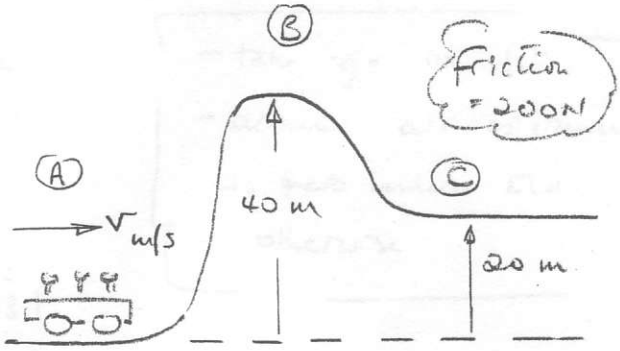
The car climbs a hill, that rises 1 m for every 40 m travelled. Friction stays the same.



(f) What engine force is needed to maintain a steady 20 m/s speed now? (2)

(g) What engine power is needed to maintain 20 m/s.? (2) [17]

3. The truck + riders, mass 500kg, roll uphill, over the top at B, and down to level C. There is no friction A to B to C — but there is 200N friction after C.



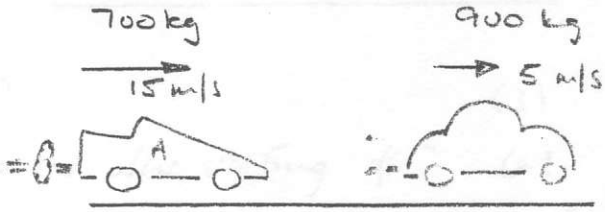
(a) What is the minimum velocity needed to get over B? (3)

(b) What is the velocity at C? (2)

(c) How far does the truck roll along the level after C? (2) [7]

4 (a) Give the Principle of Conservation of Momentum (2)

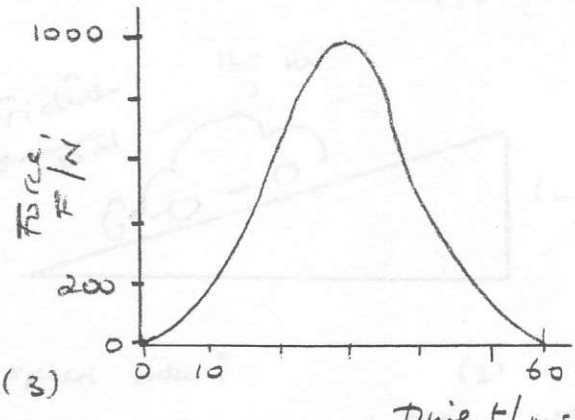
(b) What is Impulse? (2)



(c) Car A crashes into car B on a level road. The 2 cars lock together. What is their velocity after colliding? (2)

(d) What is the energy change involved in the crash? Where does the "lost energy" go, and what form is it? (4) [10]

5 A golfer hits a golf ball, mass 120g, from rest. The graph shows how the force of the ball varies with time.

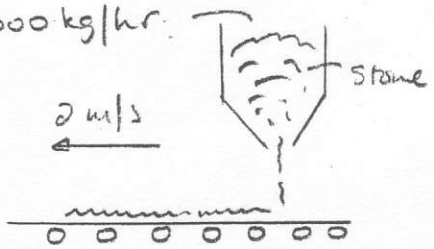


(a) What is the maximum acceleration, and when does it occur? (3)

(b) Estimate the total momentum change of the ball (2)

(c) What is the ball's speed immediately after being hit? (2) [7]

6. The conveyor belt is designed to move 2000 kg of stone per hour.



(a) What force is needed to keep the belt moving? (3)

(b) If the density of the stone is 3.2 g/cm³, what is the volume of 2000 kg? (2)

(c) The belt is driven by a 240V mains motor. What current does it take? (4) [6]

Linear Dynamics – Answers. A Physics

1 (a) – ③ (b) $F = ma$ ③ & $F = \frac{mv - mu}{t}$ ③ [9]

2. (a) $a = \Delta v / t = 1.33\ m/s^2$ ① $F_{resultant} = ma = 800\ N$ ① $\rightarrow F_{engine} = 900\ N$ ① /3

(b) v at 6s $= u + at = 8\ m/s$ ② $P_{engine} = F_{eng.} \times v = 900 \times 8 = 7200\ W$ ② /4

(c) F_{engine} at 20 m/s = 100 N /1

(d) Rate of work, $P_{friction} = F_{friction} \times v = 100 \times 20 = 2000\ W$ /2

(e) Rate of work against friction = 2000 W ① = 40 % of rate of using chemical E

so rate of chemical E consumption $= 2000 \times 100/40 = 5000$ W ①

wasted energy → Heat ① / engine — disturbing the air

— exhaust /3

(f) Uphill F_{engine} = Friction + resolved component of weight /2

$= 100 + mg \sin\theta = 100 + (600 \times 10 \times 1/40) = 250\ N$

(g) Power engine $= P_{eng.} = F_{eng} \times v = 250 \times 20 = 5000\ W$ /2 [17]

3 (a) To get over $KE_A = PE_B \rightarrow \frac{1}{2}mv^2 = mgh$ ① $\rightarrow v_{min} = \sqrt{2gh} = 28.3\ m/s$ ① /3

(b) $KE_C = PE\ loss\ (B \rightarrow C) \rightarrow \frac{1}{2}mv_C^2 = mg(40-20) \rightarrow v_C = 20\ m/s$ /2

(c) KE_C = work done against friction $\rightarrow \frac{1}{2}mv_C^2 = F_{friction} \times d \rightarrow d = 500\ m$ /2 [7]

4. (a) ② (b) Impulse – a perfume (£100) – $F \times t$, N sec.

(c) Total momentum before = total momentum after

$(m_A v_A + m_B v_B) = m_{A+B} v_{A+B} \rightarrow v_{A+B} = 9.4\ m/s$ /2

(d) Δ Energy change $= KE_A + KE_B - KE_{A+B} = 78750 + 11250 - 70,300 = 19,700$ J.

E loss → surroundings largely as heat + sound [10]

5 (a) a max at $t = 30$ ms $a_{max} = F_{max}/m = 1000/0.12 = 8300\ m/s^2$ /3

(b) Momentum change Δp = area under F/t graph

$= \frac{1}{2}$ base × height $= \frac{1}{2} \times 60 \times 10^{-3} \times 1000 = 30$ Ns /2

(c) $\Delta p = mv - mu \rightarrow$ v after hit $= \Delta P/m = 30/0.12 = 250\ m/s$ /2 [7]

6 (a) $Ft = mv - mu$ ① $\rightarrow F \times (60 \times 60) = 2000 \times 2 = 4000$

so force on belt = 1.1 Newtons ① /3

(b) Density = mass/vol $\rightarrow$ vol $= M/D = \frac{2000 \times 10^3\ \text{grams}}{3.2\ g/cm^3} = 625{,}000\ cm^3$

$(= 625\ dm^3 = 0.625\ m^3)$

(c) Power of motor $= F_{belt} \times v$ ① $= 1.1 \times 2 = 2.2$ Watts ①

So current $I = P/V$ ① $= 2.2/240 = 9$ mA ① (not a lot!) /4 [9]

FW
2.98