Linear Dynamics – Force + Motion

Sheet 1/2

A-Physics Dynamics

take $g = 10\ N/kg$.

1. **Level ground : no friction**

A man pushes a car for 20 seconds, as shown →

Calculate ... (a) acceleration 2

(b) distance moved in 20 s 2

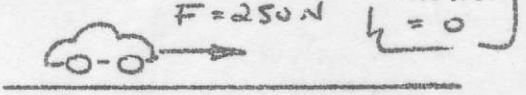
(c) work done in 20 s. 2

(d) Hence, find the car's KE at 20 s. 2

(e) Find the man's power at 20 s. 3

(f) The man stops pushing at $t = 20$ s: what does the car do? Why? 2

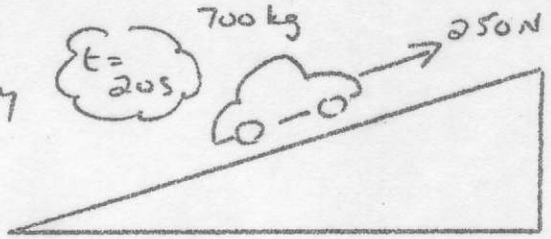
[13]



2 **Slope – still no friction**

The slope rises 1 m for every 50 m up the slope.

Otherwise – as in Q. 1.



(a) Draw a labelled diagram 4 [NOT components!]

to show the angle of the slope, and all forces acting

(b) What is the component of weight down the slope? 2

(c) Find the resultant force on the car. 2

(d) Find the acceleration up the slope. 2

At time $t = 20$ s, find ... (e) the car's velocity 2

(f) the man's power 2

(g) the P.E. gained by the car. 2

(h) If the man's maximum power is 300 W, what is the car's maximum speed up the slope? 2

[18]

3 **Level ground – friction acting**

As in Q. 1 – but constant friction force of 50 N. 4

(a) Draw a diagram to show all forces acting, and the resultant 2

(b) Find the car's acceleration

When the car has moved 50 m, calculate ... 2

(c) the work done against friction 2

(d) work done by the man 2

(e) the car's KE. 2

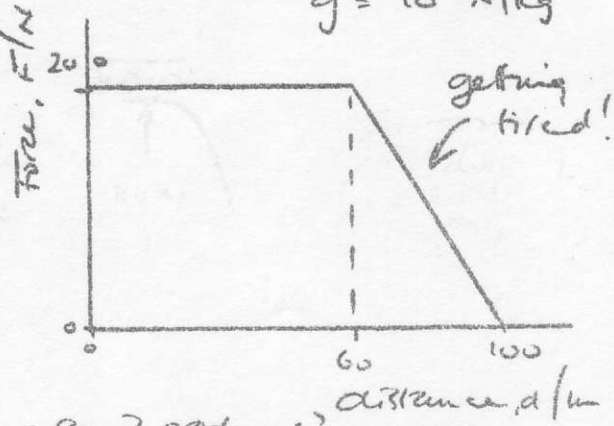
[12]

Linear Dynamics — Sheet 2/2 (continued...)

A Physics Dynamics

$g = 10\ N/kg$

4 A man slides a block of concrete along a level road. (Some Physics teachers will do anything for attention!). The block starts + ends at rest.



(a) What is the work done? 3

(b) How much energy has the work produced? What kind of energy is produced? Explain clearly how this energy is produced. 5 [8]

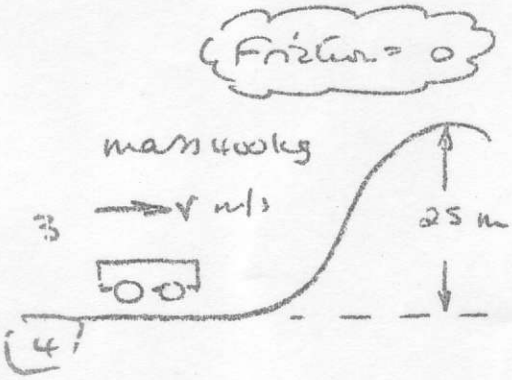
5. **Theme Park Time...**

The truck must get over the hill...

(a) What velocity is needed for....

(a) the truck just to get over the hill? 3

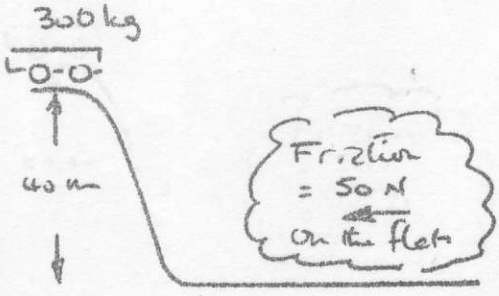
(b) the truck to have a velocity of 5 m/s at the top? 1



[4]

6. (a) How much P.E. does the truck start with? 2

(b) How far does it roll on the flat before stopping? 2 [4]



7. An electric motor pulls the truck up to the top

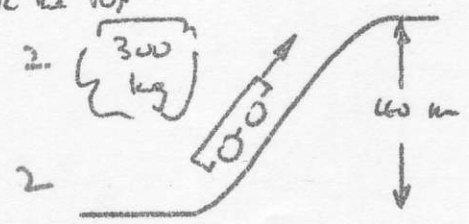
(a) How much energy must the truck gain? 2

(b) If the motor does this in 30 s, what is its power? 2

(c) "The motor is 70% efficient." Explain this. What must be the input power to the motor? 3

(d) The motor runs off 240 V mains: what current does it need? 2

(e) What is the major energy loss? Later How is this energy produced? 3



[12]

© MN 2.98. Ext. As Q.2, but with 50N friction. What is the maximum angle the man can... (a) just hold the car still? (b) just move it uphill?

Linear Dynamics – Answers — A Physics

1. (a) $a = F/m = 0.36$ m/s² (2)

(b) $s = ut + \frac{1}{2}at^2 \rightarrow \frac{1}{2}at^2 = \underline{71.4 \text{ m}}$ (2)

(c) Work $W = F \times d = 250 \times 71.4 = \underline{17,860 \text{ J}} = \underline{17.9 \text{ kJ}}$ (2)

(d) work done → KE, so KE = 17.9 kJ (1)

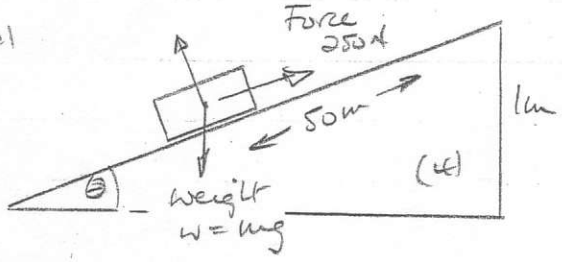
(e) Power = force × distance / time = force × v ....

$KE = \frac{1}{2}mv^2 = 17,860$ J → v = 7.1 m/s

so power $P = F \times v = 1786$ Watts, W. (3) (13)

(f) Car keeps going at the same velocity ... because no friction! (1)

2. (a)



(b) Component of weight $W_{slope} = mg \sin\theta$

$= 700 \times 10 \times 1/50$

$= \underline{140 \text{ N}}$ (2)

(c) $F_{res} = 250 - 140 = \underline{110 \text{ N}}$ (2)

(d) $a = \frac{F_{res}}{m} = 110/700 = 0.157 = \underline{0.16 \text{ m/s}^2}$ (2)

(e) $v = u + at = 0 + 0.157 \times 20 = \underline{3.14 \text{ m/s}}$ (2)

(f) man's power $P = F \times v = 250 \times 3.14 = \underline{786 \text{ Watts}}$ (2)

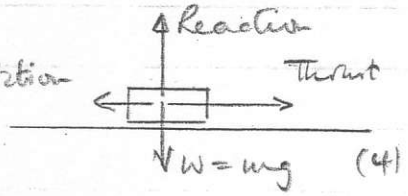
(g) PE gained by car = mgh gain = mg × (distance up slope / 50)

Distance up slope $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 0.16 \times 20^2 = \underline{31.4 \text{ m}}$

so PE gained = 700 × 10 × 31.4/50 = 4,400 J (2)

(h) $P_{max} = F \times v_{max} \rightarrow v_{max} = P/F = 300/250 = \underline{1.2 \text{ m/s}}$ (2) (19)

3. (a)



(b) $a = F_{res}/m = 200/700 = \underline{0.29 \text{ m/s}^2}$

(c) Work $W = F_{Frict.} \times 50 = \underline{2500 \text{ J}}$

$F_{res} = 250 - 50 = 200$ N.

(d) work by man $W_m = 250 \times 50 = 12,500$ J

(e) Car's KE. $F_{res} \times d = KE = 200 \times 50 = 10,000$ J of KE

or $v^2 = u^2 + 2as \rightarrow$ v after 50 m $= \sqrt{2as} = 5.34$ m/s

so $KE = \frac{1}{2}mv^2 = 10,000$ J

2.9N

work done by man 12,500 J → KE of car 10,000 J + work against friction 2,500 J

Linear Dynamics – Answers – A Physics

4 (a) work done = total of force × distance
= area under graph
= (200 × 60) + (½ × 200 × 40) = 16,000 J

(b) 16,000 J ② of Heat ① energy produced – atoms in surfaces rubbing together ①, friction ①, sets the atoms vibrating ①, gives them thermal energy. [8]

5. (a) KE = PE ① so ½mv² = mgL ① → v_{min} = 22.3 ① m/s (3)

(b) v_{min} now = 22.3 + 5 = 27.3 m/s [4] (1)

6 (a) PE = mgL = 300 × 10 × 40 = 120,000 J (2)

(b) PE → KE → work against friction = F × distance slid
so 120,000 = 50 × d → d = 2,400 m = 2.4 km !! [4]

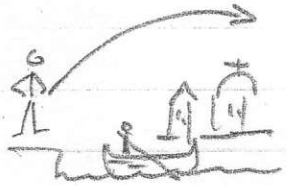
7. (a) PE gained = mgL = 300 × 40 × 10 = 120,000 J

(b) Power P = work / time = 120,000 / 30 = 4000 J/s, W.

(c) 70% efficiency = for 100 J energy input – 70J are produced
– 30 J are wasted

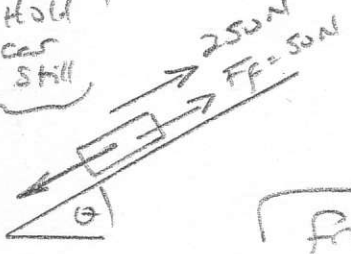
so P_{input} = 4000 × 100/70 = 5710 W. (3)

(a) P_{elec} = I × V → I = P/V = 23.8 A (2)



(c) motor energy loss = 30% of input = 30/100 × 5710 = 1700 W
produced as HEAT by – elec. heating in wires
– friction between moving parts

Ext (a) Hold car still

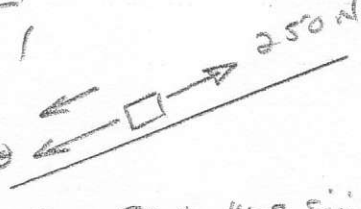


FM 2.9?

mg sinθ = 250 + 50
→ θ_{max} = 2.5°

friction force always opposes motion !!

(b) push car uphill



250 = 50 + mg sinθ
→ θ_{max} = 1.6°