Memo – Kinematics

Gr 12 Trials

August 2008

Paper I
Memorandum

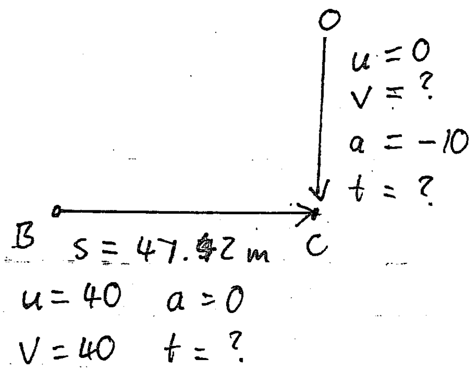
Question 1:

1.1) $\frac{80\ \text{km}}{1\ \text{hr}} \times \frac{1\ \text{hr}}{60\ \text{min}} \times \frac{1\ \text{min}}{60\ \text{sec}} \times \frac{1000\ \text{m}}{\text{km}} = 22.2\ \text{m.s}^{-1}$ ✓✓ (2)

1.2) $v^2 = u^2 + 2as$

$\therefore s = \frac{v^2 - u^2}{2a} = \frac{40^2 - 22{,}2^2}{2(1)} = 553{,}6\ \text{m}$ ✓✓ (2)

1.3)



$s = 5.8\ \text{m}$

Time for train going B to C => $v = \frac{s}{t}$ $\therefore t = \frac{s}{v} = \frac{47{,}42}{40}$ ✓✓

$= 1.186\ \text{s}$

Time for stone to fall to windscreen => $s = ut + \frac{1}{2}at^2$ ✓

$\therefore s = \frac{1}{2}at^2$

$\therefore t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2(5.8)}{(10)}}$ ✓

$= 1.08\ \text{s}$

$\therefore$ Since stone and Train do not cross paths at the same time the boys will not be successful. ✓✓ (6)

①

1.4) The total mechanical energy of a system remains constant provided no external force acts. (2)

1.5) $v^2 = u^2 + 2as$

$v^2 = 0^2 + 2(-10)(-5.8)$

$= 116$

$\therefore v = 10{,}77\ m.s^{-1}$

$\therefore E_K = \frac{1}{2}mv^2$

$= \frac{1}{2}(5)(10{,}77)^2$

$= 289{,}98\ J$

$\therefore$ the stone would not crack the windscreen (if it had struck it). (3)

1.6) $V_{TG} = 40\ m.s^{-1}$ $V_{CG} = -16{,}7\ m.s^{-1}$

$\therefore V_{TC} = V_{TG} + V_{GC}$

$\therefore V_{TC} = 40 + (+16{,}7)$

~~= 23,3 m.s⁻¹~~

$= 56{,}7\ m.s^{-1}$ (3)

1.7) Passengers will according to NI continue with their velocity ($40\ m.s^{-1}$) unless acted upon by an external force. If they were not buckled up a part of the train would apply the external force causing injury. The seat belt is a less injurious way of overcoming the passengers' inertia. (2)

(2)

1.8) conservation of momentum

$m_1 u_1 + m_2 u_2 = (m_1 + m_2)V$

$\therefore (50000 \times 11,1) + (800)(-16.7) = 50800\ V$

$\therefore V = 10,67\ m.s^{-1}$ south. (3)

1.9) $F\Delta t = m\Delta v$

$\therefore F\Delta t = 50000(10,67 - 11,1)$

$= -21\,500\ kg.m.s^{-1}$

$\therefore F\Delta t = 21\,500\ kg.m.s^{-1}$ in the Northerly direction (or N.s) (3)

1.10) $E_{k\,before} = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$

$= \frac{1}{2}(50000)(11,1)^2 + \frac{1}{2}(800)(16,7)^2$

$= 3197975.747\ J$

$E_{k\,after} = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$

$= \frac{1}{2}(50000)(10,67)^2 + \frac{1}{2}(800)(10,67)^2$

$= 2891762,06\ J$ (3)

$\therefore E_{k\,before} \neq E_{k\,after}$ $\therefore$ collision inelastic.

1.11) The kinetic energy lost would have been transferred as heat, light and sound energy. (2)

1.12) 2 functions

1 - To apply an external force to the passengers to ~~bring about~~ ~~stop th~~ resist and overcome their inertial tendency to continue with the car's velocity (in the case of airbags and seatbelts)

2 - To increase the impact time thereby decreasing the ~~impulse of the car~~ the change in momentum of the car and passengers thereby decreasing the forces acting on the passengers. (3)

1.13) ~~The train's~~ ~~Stru~~

Any two reasons like:

- Train has stronger construction therefore holding up better under the forces of the car than the car experiences from the train.
- Passengers further from point of impact ∴ less likely to experience contact forces of train body.
- Can't say that train experiences a smaller change in momentum.

(3)

Question 2

2.1) Gravitational potential energy and kinetic energy (1)

2.2.1) $v = u + at$

$\therefore u = v - at$

$u = 0 - (-10)(1.5)$

$u = 15 \text{ m.s}^{-1}$ (3)

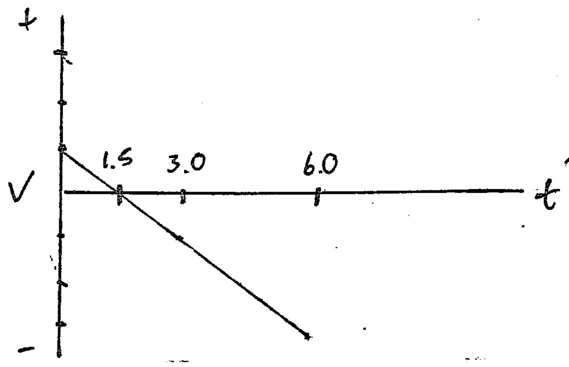
2.2.2) $v = u + at$

$v = -15 + (-10)(3)$

$= -45 \text{ m.s}^{-1}$

$\therefore v = 45 \text{ m.s}^{-1}$ downwards (3)

2.3)

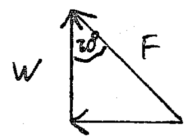


✓shape

✓time values

✓further into negative

2.4)



$w = mg$

$= 800 \times 10$

$= 8000 \text{ N}$

$\frac{w}{F} = \cos 30°$

$\therefore F = \frac{w}{\cos 30°} = \frac{8000}{\cos 30} = 9237.6 \text{ N}$ (3)

2.5) $W = F \times s$

$= 8000 \times 2$

$= 16000 \text{ J}$ (2)

2.6 Power Input = 2000 W

Power output = w/t = 16000 / 15 = 1066 W

Efficiency = output / input x 100 = 1066/2000 x 100 = 53.3 %

Question 3 [21 marks]

3.1 USA (1)

3.2 150✓/1000 = 15%✓ (2)

3.3 - lack of control over possession of driver's lisences

- poor road conditions

- police not checking for speeding often enough

- vehicles not roadworthy

(Etc) (any two answers) (2)

3.4.1 90 + 60 = 150 $km.h^{-1}$ or
41,67 $m.s^{-1}$ toward child or west (mag and dir)
(2)

✓attampt at summing

✓answer

3.4.2 In a closed system✓ the total linear momentum remains constant✓ (in both magnitude and direction) . (2)

3.4.3 $P_{before} = p_{after}$

$m_AU_A + m_BU_B = (m_A + m_B) V$ ✓

1000. 16,67 + 1500.(-25) = (1000+1500)V

✓ (two terms reasonable subst) =✓ (correct subst)

Need not get sign '-' on u_b

V = - 8,32 $m.s^{-1}$

V = 8,32 $m.s^{-1}$ west✓ 0r 30 $km.h^{-1}$ west (4)

3.5.4 The child will continue to move forward✓ at 60 km.h^{-1}. because of his/her inertia.✓ It will hit the front dashboard, window or seat.✓ (3)

3.5.5 The windscreen moves west at 8,32 m.s^{-1} while child moves east at 16,67 m.s^{-1}. $V_{cw} = V_{cr} + V_{rw}$ ✓

V_{cw} = 8,29 + 16,67

V_{cw} = 24,96 m.s^{-1} ✓(2)

3.5.6 Head would continue to move forward✓ and neck muscles are not fully developed✓ so neck will be hurt.✓ (3)

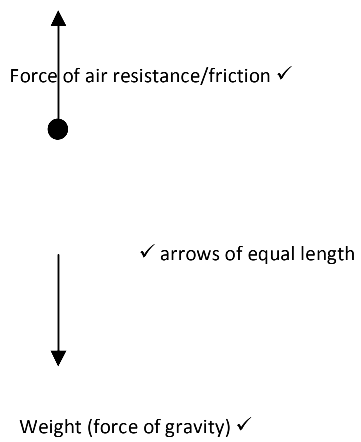
Question 4 [28 Marks]

4.1.1 A (1)

4.1.2 10 m.s^{-2} down ✓ (both mag and dir) (1)

4.1.3 D (1)

4.1.4



(3)

4.1.5 C (1)

4.1.6 A. Fig P E. Fig S or Fig R

B. Fig Q or Fig T (3)

4.2.1 The larger the surface area of a parachute, the less time taken to reach terminal velocity (2)

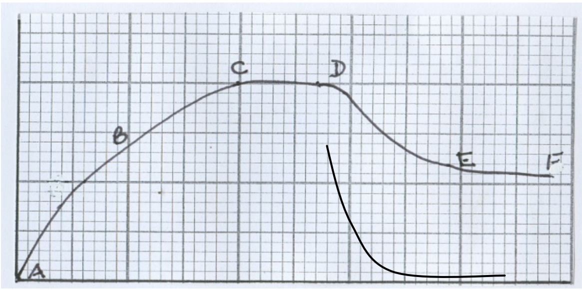
✓ reasonable statement (could be the other way round)

✓ mentions variables surf. Area and time

4.2.2 Surface area of parachute (1)

4.2.3 The material of parachute and the mass of the jumper and equipment, and the shape of the parachute.
Height from which they jumped, weather conditions etc (any 2) (2)

4.2.4 (3)



4.3.1 u =0 g = 10 $m.s^{-2}$ s = 320 m $v^2 = u^2 + 2gs$ √

$V^2 = 0 + 2.10.320$√

V = 80 $m.s^{-1}$√ (3)

Or mgh = ½ $m.v^2$

80.10.320 = ½ (80) v^2√

V = 80 $m.s^{-1}$ √

4.3.2 $E_k = ½ mv^2$

$E_k = ½ . 80. 5^2$ √

E_k = 1000J √ (2)

4.3.3 E_k if nor air friction:

$= ½ mv^2$

$= ½ 80. 80^2$

= 256000 J √

E_k lost = work done √ (attempt to find dif)

= 256000 - 1000J

= 255000 J √ (3)

4.3.4 F△t = mv –mu

F. 0,5 = 80(0-5) √

F = - 800N

= 800N up √ (mag and dir)

(2)

5.1 By calculating $E_p = mgh$ ✓ and then applying the cons. of Energy ✓ E_k at bottom = E_p at top

$\frac{1}{2}mv^2 = mgh$

$v = \sqrt{2gh}$ ✓ (3)

5.2 The total momentum in a closed system remains constant

5.3 $p = (m_1 + m_2)v$ ✓

$= (0,5 + 0,002)(0,48)$ ✓

$= 0,24$ kgms^{-1} ✓ up the slope ✓ (2)

5.4

$p_b = p_a$ ✓

$\therefore mv = 0{,}24$ ✓

$0{,}002v = 0{,}24$

$\therefore v = 120\ m s^{-1}$ ✓ (3)

5.5

It is a collision in which kinetic energy is not conserved. ✓

E_k before $= \frac{1}{2}mv^2$
$= \frac{1}{2}(0{,}002)(120)^2$
$= 14{,}4\ J$ ✓

after $= \frac{1}{2}mv^2$
$= \frac{1}{2}(0{,}502)(0{,}48)^2$
$= 0{,}058\ J$ ✓

5.6

Although the pellet does not have enough energy to pierce ✓ skin it can still cause ✓ sever harm if shot into softer tissue like eyes ✓ (3)

6)

6.1	$0\ m.s^{-2}$ ☚	✓✓	(2)
6.2	$10\ m.s^{-2}$ ☚	✓✓	(2)

6.2	Velocity increases	✓✓	
	Mass decreases, from Newton II, $m \propto \frac{1}{a}$. Therefore acceleration increases. Since F $\propto$ a, F_R upwards increases ☚	✓✓✓	(4)

6.3	s = ?	$v^2 = u^2 + 2as$	✓	
	t =	$0^2 = (-5)^2 + 2(10)s$	✓	
	$u = -5\ m.s^{-1}$	$s = -1,25\ m$	✓	
	$v = 0\ m.s^{-1}$	$\therefore s$ = 1,25 m upwards + 100		
	$a = 10\ m.s^{-2}$	∴ **Maximum height (P) is 101,25 m** ☚	✓	(4)

6.4	s =			
	t = ?	$v = u + at$	✓	
	$u = -5\ m.s^{-1}$	$0 = -5 + 10t$	✓✓	
	$v = 0\ m.s^{-1}$	$\therefore$ ***t* = 0,5 s** ☚	✓	
	$a = 10\ m.s^{-2}$			(4)

6.5

$s = 100$ m	
$t = ?$	
$u = -5$ m.s^{-1}	
$v =$	
$a = 10$ m.s^{-2}	

$s = ut + ½at^2$ ✓

$100 = (-5)t + ½(10)(t)^2$ ✓

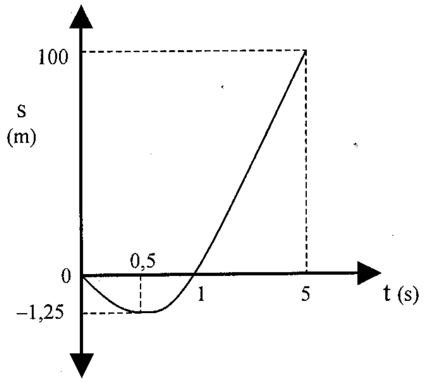
$100 = -5t + 5t^2$

$0 = t^2 - t - 20$

$0 = (t + 4)(t - 5)$ $[t \neq -4]$ ✓

$\therefore$ ***t* = 5 s** ☚ ✓ (4)

6.6



✓✓✓
✓✓

Note: down is taken as positive (5)

Question 7

7.1 In the same direction as the motion of the truck ☚ **/ E** ✓✓ (2)

7.2 10 km.h^{-1} towards back of truck ☚ ✓✓ (2)

Question 8

8.1 **total** momentum before a collision✓ = **total** momentum after a collision ✓or total momentum of a constant
or

mv = 0 , where *mv* is the momentum no external forces acting on the system/ isolated system

8.2.1 work done = *F s* ✓ = 7 500 x 8,4
63 000 J✓

8.2.2 KE = ½ mv^2 ✓ or $F = ma$ and $v^2 = u^2 + 2as$
63000 = ½(600) v^2 combined speed 7 500 = 600a 0 = u^2 +
2(1,25)(8,4)

v = 4.6 (4.58) m s^{-1}✓ u = 4,58 m.s^{-1}

(2)

8.2.3 reasonable attempt at a momentum conservation equation✓
(2 terms before and one term after any signs)

(+ or -) 3600 v + (2400 × 12.5) = (6000 × 4.58) (e.c.f) ✓

16 ms^{-1} left (cao ignoring sign) ✓ (

8.2.4 driver A✓ is likely to experience the greater force
force = rate of change of momentum (□*mv*/*t*) or *F* = *ma*
time for deceleration on impact is (approximately) the same✓
change in velocity of driver B = 11.4 m $^{s-1}$ (ecf from (ii) and (iii)) ✓
and
change in velocity of driver A = 17.1 m s^{-1} (ecf from (ii) and (iii)) ✓
or
Δmv or Δv of A > Δmv or Δv of B

8.2.5 The seatbelt ensures that the person becomes part of the car so when a resultant force ✓is applied

on the car to brake it, the person will also slow down and will not continue to move forward✓ due

to it's inertia. This will prevent the person from hitting the windscreen. ✓ (3)

9.1 X

9.2 1.39 ms^{-1}

9.3

$E_m = E_k + E_p$ ✓

$= \frac{1}{2}mv^2 + mgh$

$= \frac{1}{2}(1500)(1,39)^2 + 1500(10)(25)$ ✓ ✓

$= 1\ 449,075 + 375\ 000$

$= 376\ 449,08$ J ✓ (4)

9.4

At Y $E_m = 376\ 449,08$ ✓

$\therefore \frac{1}{2}(1500)v^2 + 1500(10)(7) = 376\ 449,08$

$\therefore 750\ v^2 = 271\ 449$ ✓

$v^2 = 361,93$ (3)

$v = 19$ ms^{-1} ✓

10.1 The rate at which work is done ✓ (2)

10.2 The ability to do work ✓ (2)

10.3 $P = \frac{W}{t}$

$\therefore W = P \cdot t$ ✓

$= 90\,000(17 \times 60)$ ✓

$= 91\,800\,000$ J ✓ (2)

10.4 $E_p = mgh$ ✓

$= 4000(10)(2200)$ ✓

$= 88\,000\,000$ J ✓ (2)

10.5 Loss of energy to heat / sound / friction ✓✓ (2)

11.1 $\Delta p = m(v - u)$ ✓

$= 1{,}5(0 - 30)$ ✓

$= -45\ \text{kg.m.s}^{-1}$ ✓

$= 45\ \text{kg.m.s}^{-1}$ left ✓ (4)

11.2 $F\Delta t = \Delta p$ ✓

$F \times 1 = -45$ ✓

$F = 45$ N left (This is the force the car exerts to the left.)

$\therefore$ Force of water on car is 45 N right. ✓ (3)

11.3 If motion to the right is regarded as positive, $u = \oplus$ value and $v = \ominus$ value ✓

$\Delta p = m(v - u)$ ✓

$\Delta p = m(\ominus - \oplus)$

$\Delta p = m($ larger negative value$)$

$\Delta p =$ larger value ✓

Since $F\Delta t = \Delta p$, larger p implies a larger F. Force is thus larger. ✓ (4) **[11]**

12.1 $(E_{\text{mech}})_{\text{top}} = (E_{\text{mech}})_{25\text{ m lower}}$ ✓

$(E_P)_{\text{top}} = (E_P)_{25\text{ m lower}} + (E_K)_{25\text{ m lower}}$ ✓

$75 \times 10 \times 60 = 75 \times 10 \times 35 + E_K$ ✓✓

$E_K = 18\ 750\text{ J}$ ✓ (5)

12.2 $W = \Delta E_K$ ✓

$= 18\ 750 - 0$ ✓✓

$= 18\ 750\text{ J}$ ✓ (4)

12.3 18 750 J ✓✓ (2)

12.4 Principle of conservation of energy ✓✓ (2)

12.5 $W = \Delta E_K$ ✓

$Fs = 18\ 750$ ✓

$F.20 = 18\ 750$ ✓

$F = 937{,}5$ N upwards ✓ (4) **[17]**