Casio fx-911Z

Registration Number

0352624

Candidate Name Tan Zhi Yong

NATIONAL JUNIOR COLLEGE
JC 1 TERM 3 COMMON TEST
SECTIONS B & C

PHYSICS **9248**

Thursday 3 July 2003 1 h 40 min

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.

Write your **name** and **registration number** in the spaces at the top of this page.

You are given **1 hour 40 minutes** to complete **Sections B** and **C**.

Section B [60 marks]

Answer **ALL** questions.

Write your answers in the **spaces provided on the question paper.**

For numerical answers, **all working should be shown.**

The number of marks is given in brackets [ ] at the end of each question or part question.

Section C [20 marks]

Answer the question in this section.

Write your answers on the **writing paper** provided.

For numerical answers, **all working should be shown.**

The number of marks is given in brackets [ ] at the end of each question or part question.

F

FOR EXAMINER'S USE	
Section A	
1 to 20 Subtotal	30

FOR EXAMINER'S USE	
Sections B, C	
Qn	Marks
21	$9\frac{1}{2}$
22	8
23	$8\frac{1}{2}$
24	10
25	9
26	10
27	
Subtotal	

Total	:	73-75 / 120
Percentage:		
Grade	:	

This section consists of 17 printed pages including this cover page.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
gravitational potential,	$\phi = -\dfrac{Gm}{r}$
refractive index,	$n = \dfrac{1}{\sin C}$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \dfrac{Q}{4\pi\epsilon_0 r}$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
energy of charged capacitor,	$W = \frac{1}{2}QV$
alternating current/voltage,	$x = x_0 \sin \omega t$
hydrostatic pressure,	$p = \rho gh$
pressure of an ideal gas,	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$

Section B [60 marks]

21 **Fig. 1** shows an idealised velocity-time graph, and the corresponding acceleration-time graph, for a journey of a train between two stations on an underground system.

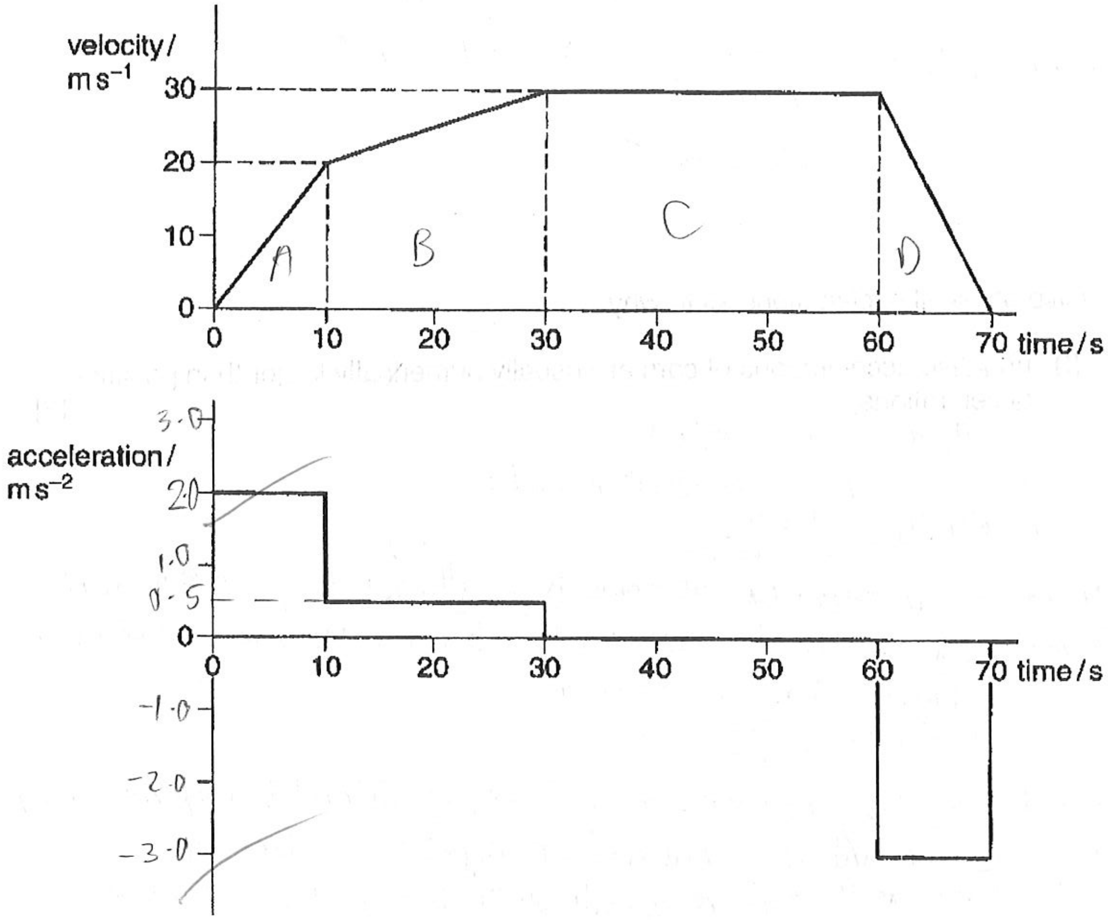


Fig. 1

(a) By making suitable calculations, mark values on the *y*-axis of the acceleration-time graph in **Fig. 1** above. [2]

~~Acceleration at first part of journey =~~

Acceleration at $A = \frac{20-0}{10-0}$

$= 2.0 \text{ ms}^{-2}$

Acceleration at $B = \frac{30-20}{30-10}$

$= 0.5 \text{ ms}^{-2}$

Acceleration at $D = \frac{0-30}{70-60}$

$= -3.0 \text{ ms}^{-2}$

21(b) Calculate the average velocity of the train between the 10th and the 70th seconds. [2]

Displacement between 10th and 70th seconds $= \frac{1}{2}(30-10)(20+30) + \frac{1}{2}(30)(60-30+70-30)$

$= 500 + 1050$

$= 1550m$

Average velocity $= \frac{1550}{(70-10)}$

$= 25.8\ ms^{-1}$

(c) Give physical explanations as to why

(i) negative accelerations of cars are usually numerically larger than positive accelerations, [2]

< a as result of braking

OR > a due to driving force from engine

Braking force do not require to be work done

Power = Force × velocity

= Mass × Acceleration × velocity

Acceleration $= \frac{\text{Power}}{\text{Mass} \times \text{velocity}}$

OR

drive forces require work to be done

Output power not ↑ enough to give large accelerations

The power ~~of~~ a car engine can generate is small, hence its positive acceleration is small. The mass of a car is also huge and this decreases the positive acceleration.

Force = Mass × Acceleration

Acceleration $= \frac{\text{Force}}{\text{Mass}}$

When a car brakes, the frictional force delivered by the road is very huge compared to the mass of the car and this creates a large negative acceleration.

∴ negative accelerations are usually larger than positive accelerations.

$\frac{1}{2}$

(ii) parts of acceleration-time graphs for cars can almost be vertical but velocity time graphs for vehicles can never be vertical. [3]

Acceleration $= \frac{\Delta \text{velocity}}{\text{time}}$

A car can change its velocity at a constant rate, hence acceleration can change suddenly and this creates a vertical line on a acceleration-time graph.

Velocity-time graphs can never be vertical as this will cause the car to jerk suddenly. ?

Gradient of velocity-time graph is a

Infinite a not possible

But a is directly proportional to force on car and force can be changed suddenly.

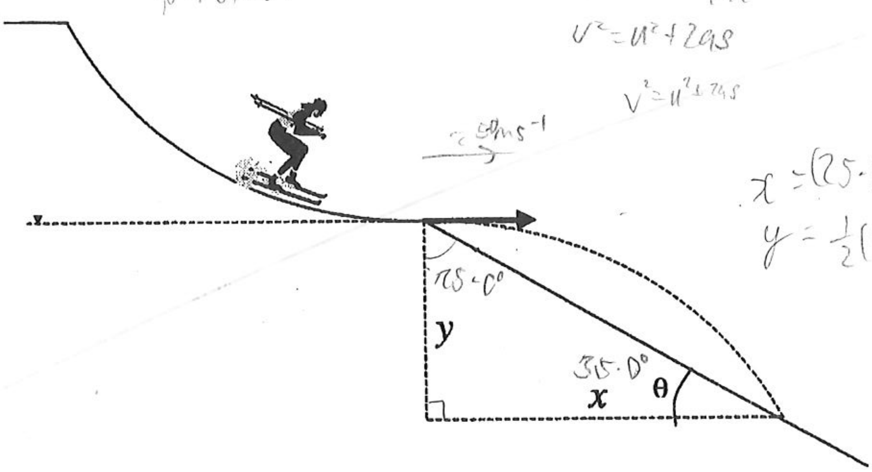
OR use graphs for illustration

22 A ski jumper travels down a frictionless slope and leaves the ski track with a horizontal speed of 25.0 m s^{-1}. The landing incline below him falls off with a slope of θ = 35.0°. Assume that the ski jumper starts from rest at the top of the slope and travels down the slope under the action of the gravitational field only.

$v = u + at$

$s = ut + \frac{1}{2}at^2$

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



$x = (25.0)t$

$y = \frac{1}{2}(9.81)t^2$

(a) How long is he airborne? [5]

$y = \frac{1}{2}(9.81)t^2$

$x = (25.0)t$

$\tan 35.0° = \frac{y}{x}$

$= \frac{\frac{1}{2}(9.81)t^2}{(25.0)t}$

$= 0.1962t$

$t = \cancel{0.28s}$ 3.57 s

$s_x = u_x t$

$x = (25.0)t$ —(1)

$s_y = u_y t + \frac{1}{2}gt^2$

$y = \frac{1}{2}gt^2$ —(2)

$\tan 35° = \frac{y}{x}$ —(3)

$\frac{\frac{1}{2}gt^2}{25t} = \tan 35°$

$t = 3.57s$ (3s.f)

5

$x = 25t$

$y = \frac{1}{2}gt^2$

$\frac{y}{x} = \tan 35°$

$\frac{gt^2}{2(25)t} = \tan 35°$

$t = \frac{50 \tan 35°}{g}$

22(b) How far down the incline does he land? working ? [3]

Distance $= \frac{1}{2}(9.81)(3.569)^2$ ※

$= 62.5\text{ m}$

$\frac{1}{2}$

$x = V_x t$

$= (25.0)(3.568)$

$= 89.2\text{ m}$ — (1)

$y = \frac{1}{2}gt^2$

$= \frac{1}{2}(9.81)(3.568)$

$= 62.4\text{ m}$

Length of slope $= \sqrt{89.2^2 + 62.4^2}$

$= 109\text{ m}$

(c) What is the speed of the ski jumper just before he lands? [3]

Speed $= \sqrt{[(9.81)(3.569)]^2 + 25.0^2}$ working ?

$= 43.0$ ~~ms-1~~ ms^{-1}

$2\frac{1}{2}$

$V_x = u_x$

$= 25.0\text{ ms}^{-1}$

$V_y = u_y + gt$

$= (9.81)(3.568)$

$= 35.0\text{ ms}^{-1}$

$V = \sqrt{V_x^2 + V_y^2}$

$= 43.0\text{ ms}^{-1}$

3

23(a) State what is meant by a *perfectly elastic collision.* [1]

A perfectly elastic collision occurs when the total momentum and kinetic energy of two colliding bodies remains constant after collision.

In a perfectly elastic collision, total kinetic energy is conserved.

(b) A steel ball is released from rest at a height of a few centimetres above a fixed horizontal steel surface. It falls on to the surface and bounces.
State and explain whether or not the collision between the ball and the surface is perfectly elastic, and provide simple observational evidence for your answer. Details of an experiment are **not** required. [2]

No, the collision is not perfectly elastic. ~~Some energy~~ The kinetic energy of the ~~stell~~ steel ball has been reduced as some energy is lost as heat or sound energy. ~~And over~~ the ball does not return to the original height.

(c) An isolated nucleus of a radioactive element has a mass of 3.5×10^{-25} kg. While it is at rest the nucleus emits an alpha particle of mass 6.7×10^{-27} kg with kinetic energy 1.4×10^{-12} J. Calculate:

(i) the speed of the alpha particle; [2]

$\cancel{\frac{1}{2}m}$ kinetic energy $= \frac{1}{2}mv^2$

$1.4\times10^{-12} = \frac{1}{2}(6.7\times10^{-27})v^2$

$v = \sqrt{\dfrac{1.4\times10^{-12}}{\frac{1}{2}(6.7\times10^{-27})}}$

$= 2.0\cancel{4} \times 10^7 \ ms^{-1}$

23(c) (ii) the momentum of the alpha particle [2]

Momentum $= mv$

$= 6.7 \times 10^{-27} \times 2.0 \times 10^{7}$

$= 1.4 \times 10^{-19}$ kgms^{-1}

2

(iii) the recoil speed of the resulting nucleus. [3]

Mass of nucleus after emitting alpha particle $= 3.5 \times 10^{-25} - 6.7 \times 10^{-27}$

show? $= 3.43 \times 10^{-25}$ kg

$(3.43 \times 10^{-25}) V = 1.4 \times 10^{-19}$

$V = 4.1 \times 10^{5}$ ms^{-1}

2

By principle of conservation of linear momentum,

$0 = mv_1 + Mv_2$

$mv_1 = Mv_2$

mass of recoiling nucleus = mass of nucleus $- m$,

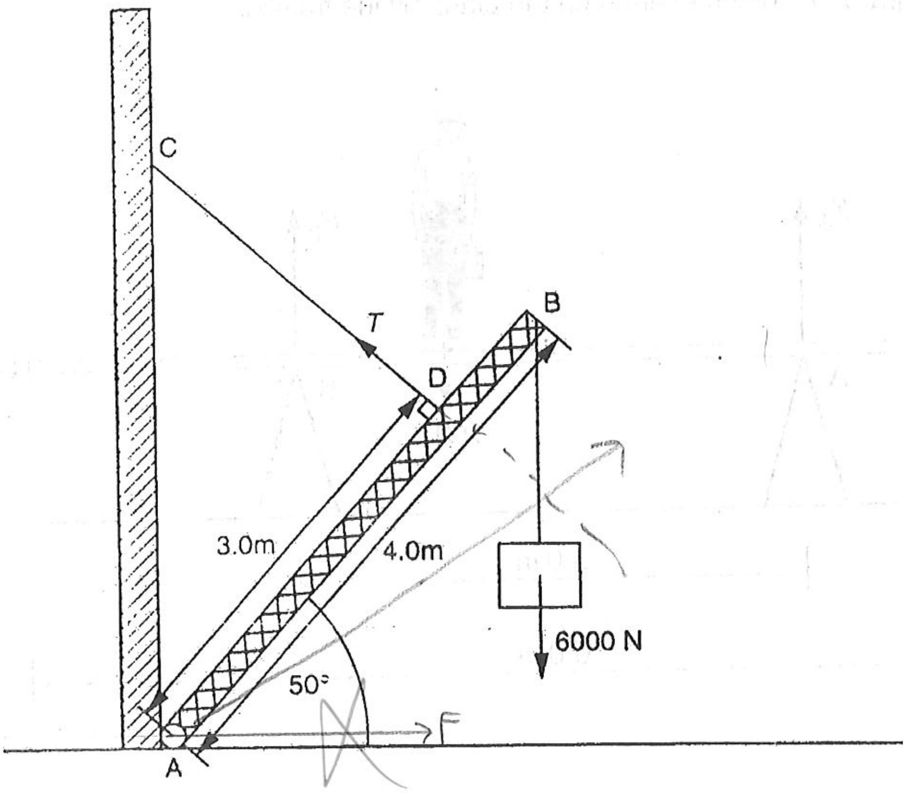
Recoil speed = momentum of alpha particle / M

$= \frac{(1.37 \times 10^{-19})}{(3.5 \times 10^{-25} - 6.7 \times 10^{-27})}$

$=$

24(a) A crane consists of a rigid strut **AB**, hinged at its base and attached to a vertical mast by a rope CD, as shown in the figure below.

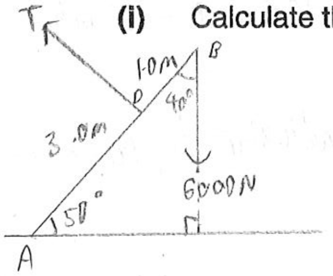
3.433×10^{-25}



6

AB is 4.0 m long and makes an angle of 50° with the horizontal. The rope meets the strut at right angles at a distance of 3.0 m from **A**. The crane supports a load of 6000 N. Neglect the weight of the strut.

(i) Calculate the tension ***T*** in the rope **CD**. [3]



Taking moment about A,

$$T(3.0) = \cancel{(6000)(}$$
$$(6000 \sin 40°)(4.0)$$

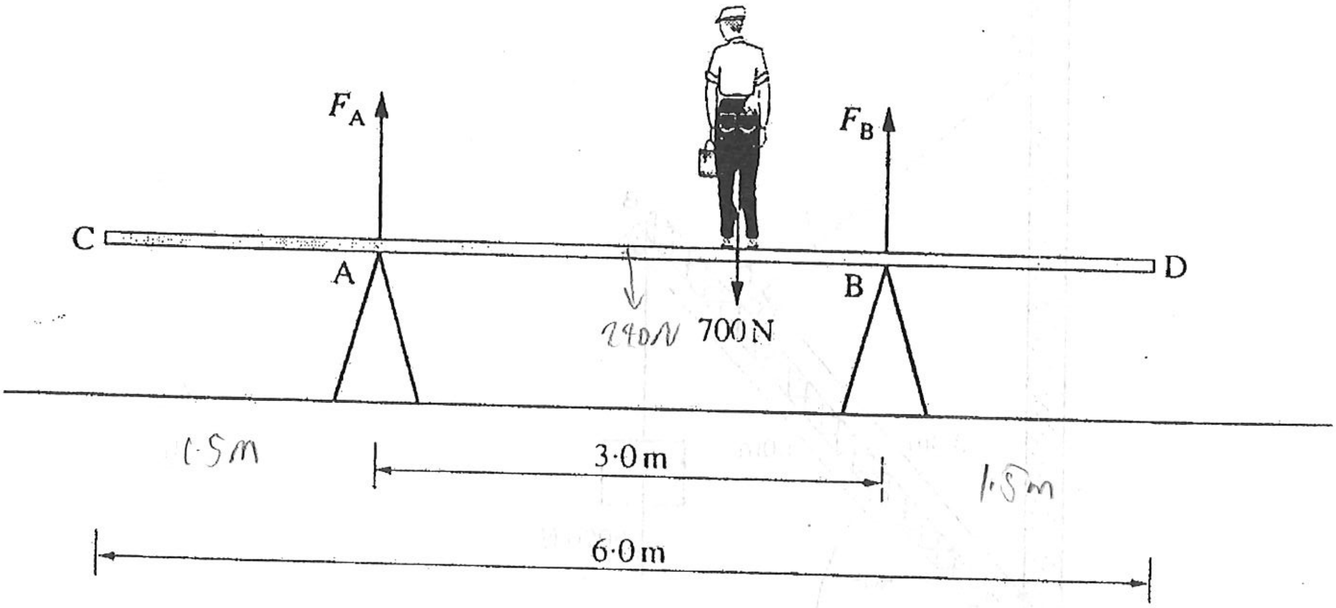
$$T = 5140\ N$$

3

$$T(3.0) = 6000(4\cos 50°)$$
$$T = 5140\ N$$

(ii) Draw the force acting on **AB** at **A** in the figure above. [1]

24(b) The figure below shows a painter standing on a uniform plank, **CD**, 6.0 m long. The plank rests symmetrically on two trestles **A** and **B** placed 3.0 m apart. The painter has a weight of 700 N, and the plank has a weight of 40 N per metre of its length. F_A and F_B are the forces exerted on the plank by the trestles.



(i) Predict in general terms, without calculation, how the values of F_A and F_B will change when the painter walks from **A** to **B** along the plank. [1]

~~As the pa~~ Taking moments about the painter, as he goes ~~closer~~ further from A and closer to B, ~~the moment of A will increase w/ while the moment of B will decrease.~~

Moment = Force × ~~distance~~ perpendicular displacement

$$\text{Force} = \frac{\text{Moment}}{\text{perpendicular displacement}}$$

Therefore ~~the force at A~~ FA will ~~increase while~~ decrease while ~~the~~ FB ~~force at B~~ will increase.

(700)(1) + (240)(·5) = 3FA

FA =

24(b) (ii) Calculate the value of F_B when the painter stands on the plank between the trestles, 1.0 m from trestle **B**. [2]

Taking moment at ~~FA~~ A,

Weight of plank = 40 × 6.0
= 240 N

~~Displ~~ Distance of centre of gravity of plank from A = $\frac{3.0}{2}$
= 1.5 m

Distance of painter from A = 3.0 − 1.0
= 2.0 m

$(700)(2.0) + (240)(1.5) = F_B (3.0)$

$F_B = 590$ N

2

(iii) Deduce the value of F_A under these conditions. [2]

Taking moment at ~~Fa~~ B,

$(3.0)(F_A) = 700(1) + 240(1.5)$

$F_A = 350$ N

2

Total upward forces = Total downward forces

$587 + F_A = 700 + (40 \times 6.0)$

$F_A = 353$ N (3s.f)
or
350 N (2s.f)

(iv) State and explain what will happen if the painter moves steadily to the right past trestle **B** towards the end **D** of the plank. [2]

The weight of the painter and the plank will ~~rest only~~ concentrate on trestle B more as he moves right. Explain: As he passes B, W of man now

Taking moments at B,

$(240)(1.5) = 700 d$

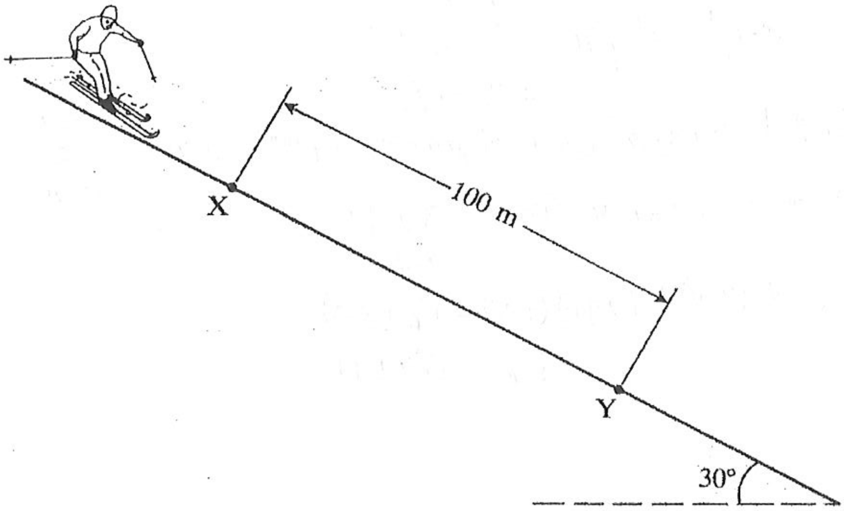
$d = 0.51$ m

2

When the painter is ~~more than~~ 0.51m away from B, the weight of the trestle and himself will rest only on B. If he walks further away, ~~the plant wi~~ plank will tilt clockwise and drop down as his moment will be greater than the moment exerted by the plank on ~~the~~ trestle B.

The plank will rotate in a clockwise manner abt point B. The man will then fall off the plank.

25 During ski-ing trials, a skier of mass 60 kg descends a slope inclined at 30° to the horizontal as shown in the diagram below. The skier passes a point **X** at a speed of 10 ms^{-1} and a second point **Y**, 100 m further down the slope, at a speed of 20 ms^{-1}.



(a) Calculate for the descent from **X** to **Y**:

(i) the gravitational potential energy change E_p of the skier; [2]

Gravitational potential energy change $= 60 \times 9.81 \times 100 \sin 30°$

$= -29430$ J

$\Delta GPE = mg\,\Delta h$

$= mg(100 \sin 30°)$

$= 60(9.81)(100 \sin 30°)$

$= 29430$ J

(ii) the kinetic energy change E_k of the skier; [2]

Change in kinetic energy $= \frac{1}{2}m(20)^2 - \frac{1}{2}m(10)^2$

$= \frac{1}{2}(60)[20^2 - 10^2]$

$= 9000$ J

$\Delta KE = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$= \frac{1}{2}m(v^2 - u^2)$

$= \frac{1}{2}(60)(20^2 - 10^2)$

$= 9000$ J

25(b) What is the mean force F of resistance to forward motion experienced by the skier between X and Y ? [2]

Mean Force of resistance $= \frac{29430 - 9000}{100}$

$= \cancel{294.3N}$ 204 N

Loss in GPE = Gain in KE + Energy Loss

$29430 = 9000 + E_F$

$E_F = 20430$

$20430 = F_R(100)$

$F_R = 204.3N$

2

(c) What is the power efficiency of the skier in the entire journey from X to Y? [2]

Power efficiency $= \frac{9000}{29430} \times 100\%$

$= 30.6\%$

Power efficiency = $\frac{\text{Useful Energy Output}}{\text{Energy Input}}$

$= \frac{\Delta KE}{\Delta PE}$

$= \frac{9000}{29430}$

$= 0.306$

$= 30.6\%$

2

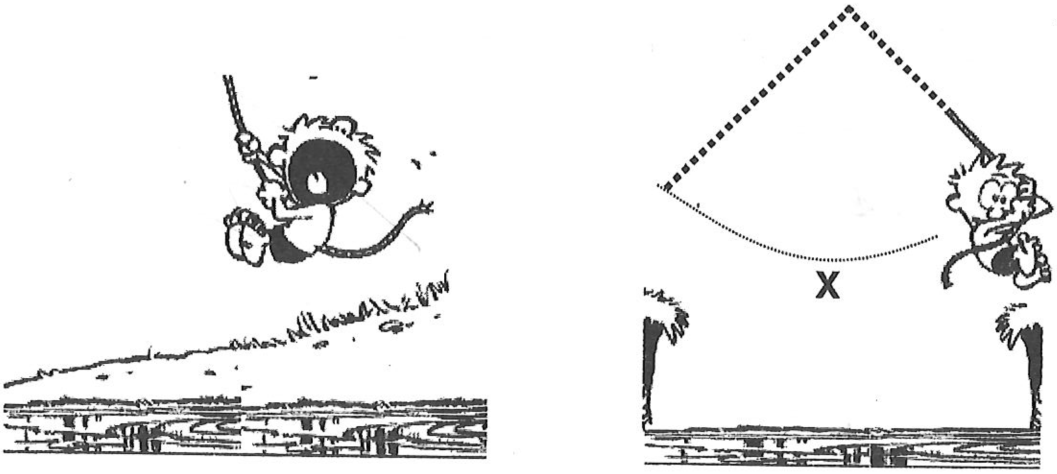
(d) State the energy transformations that the skier underwent from the top of the slope to the bottom of the slope. [1]

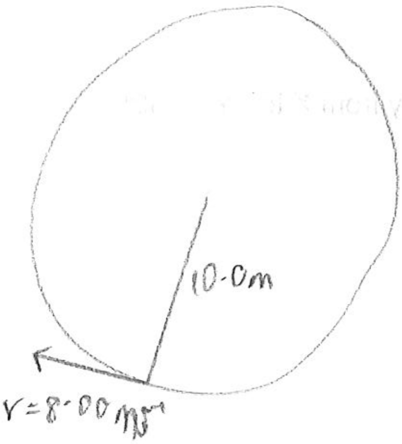
Gravitational potential energy was converted to kinetic energy, heat energy and sound energy.

GPE → KE + Heat

1

26(a) Tarzan (m = 85.0 kg) tries to cross a river by swinging from a vine as shown below. The vine is 10.0 m long, and his speed at the bottom of the swing (point **X**) is 8.00 ms^{-1}. Tarzan doesn't know that the vine can withstand a maximum tension of 1000 N before breaking.
Determine whether Tarzan can make it across the river. [4]





~~& Centripetal force = Weight of Tarzan~~

$$\cancel{\frac{mv^2}{r} = mg}$$

$$\cancel{\frac{v^2}{r} = g}$$

$$\cancel{\frac{(8.00)^2}{10.0} =}$$

Centripetal force $= \frac{mv^2}{r}$

$= \frac{(85.0)(8.00)^2}{10.0}$

$= 544N$

Weight of Tarzan $= 85.0 \times 9.81$

$= 834N$

Total tension on vine $= 834 + 544$

$= 1378N$

$> 1000N$

$\therefore$ the vine will break. Tarzan cannot make it.

By Newton's 2nd Law:

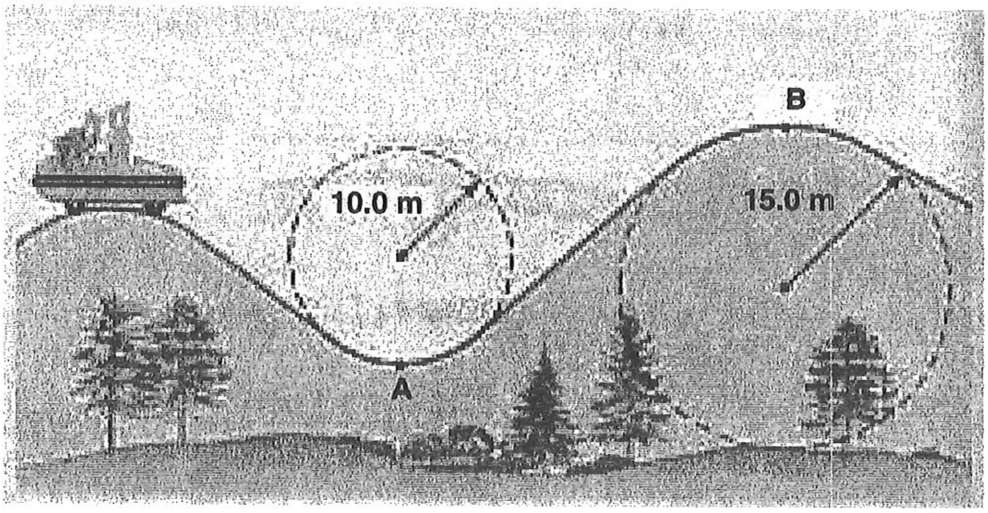
$T - mg = 544$

$T = 1378 N$

Since T at bottom > T_{max} rope will break & Tarzan will not be able to cross successfully.

4

26(b) A roller coaster vehicle has a mass of 500 kg when fully loaded with passengers as shown below.



(i) If the vehicle has a speed of 20 ms^{-1} at point A, what is the force exerted by the track on the vehicle at this point? [3]

$$Force = \frac{mv^2}{r} + mg$$
$$= \frac{(500)(20)^2}{10.0} + (500)(9.81)$$
$$= 24900 N$$

3

Resultant (Centripetal Force) = 20000 N

By Newton's 2nd Law, $R - mg = 20000$

$$R = 24900 N$$

(ii) What is the maximum speed the vehicle can have at B and still remain on the track? [3]

Centripetal force = Weight

$$\frac{mv^2}{r} = mg$$
$$v^2 = rg$$
$$v = \sqrt{rg}$$
$$= \sqrt{15.0 \times 9.81}$$

∴ max speed $= 12.1\ ms^{-1}$

By Newton's 2nd Law:

$$mg - R = \frac{mv^2}{r}$$

At max speed, $R = 0$

$$\frac{mv^2}{r} = mg$$

3

6

Section C [20 marks]

Write your answers on the **writing paper** provided.

27(a) The coyote, in his relentless attempt to catch the elusive roadrunner, loses his footing and falls vertically over a sharp cliff 150 m above the ground level. After 5.0 s of free fall, the coyote remembers he is wearing his Acme rocket-powered backpack, which he turns on to give himself an upward constant acceleration.

(i) What is the distance the coyote falls through in the first 5.0 s and what is his speed at the end of this interval? [4]

(ii) If the coyote arrives at the ground with a gentle landing (i.e. with zero vertical velocity), what is the acceleration of the motion after the rocket is switched on? [3]

$v = u + at$

$s = ut + \frac{1}{2}at^2$

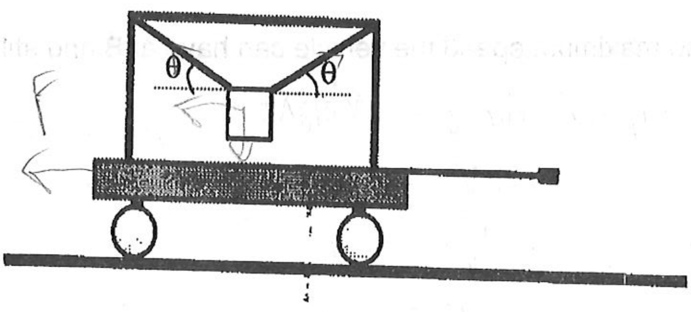
$v^2 = u^2 + 2as$

(b) If a sports car collides head-on with a massive truck, which vehicle experiences the greater impact force?
Which vehicle experiences the greater acceleration during the collision?
In each case, explain your reasoning. [2]

$F = ma$ mv $\frac{1}{2}$

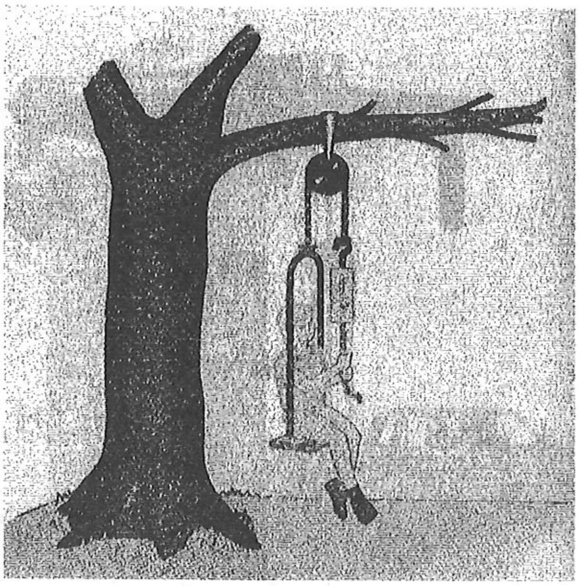
$P = \frac{E}{t} = \frac{Wd}{t}$, $Wd = Fs$, $F = \frac{Wd}{s}$

(c) A block is suspended inside a wooden crate, which is placed on a child's wagon as shown. Someone pulls on the wagon, causing the whole system to move to the right. At this instant shown below, the wagon is slowing down due to the friction acting on the wheels.



Which string exerts the larger tension force on the block? Explain. [2]

27(d) An inventive child named Brandon wants to reach an apple in a tree without climbing the tree. Sitting in a chair connected to a rope that passes over a frictionless pulley, he pulls on the loose end of the rope with such a force that the spring scale reads 250 N. His true weight is 320 N, and the chair weighs 160 N.



(i) Draw labelled free-body diagrams for

1. the chair alone, and [2]
2. Brandon and the chair considered together as one system. [2]

(ii) Show that the acceleration of the system is upward and find its magnitude. [3]

(iii) Find the force that Brandon exerts on the chair. [2]

************************* End of Paper *************************