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Registration Number
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NATIONAL JUNIOR COLLEGE
JC 1 PROMOTIONAL EXAMINATION
SECTION A

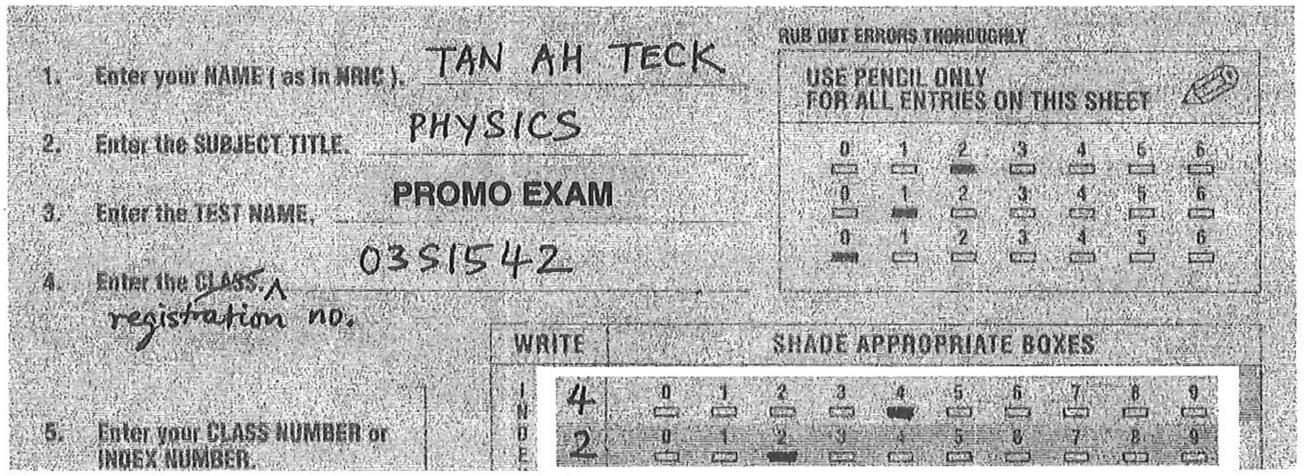
PHYSICS | **9248**
Wednesday | 15 October 2003 | 40 min

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.

Section A [40 marks]

You are given **40 minutes** on this Section. Answer **ALL** the **20** questions.
Fill in the following information on the **Optical Answer Sheet (OAS)** provided and shade the appropriate boxes as shown below:



Only **last 2 digits** of registration number

For each question there are 4 possible answers, **A, B, C** and **D.** Choose the **one** you consider correct and **shade** your choice in the boxes on the **OAS**.
Use a soft pencil (B or 2B). Rub out any answer you wish to change.

This section consists of 8 printed pages including this cover page.

$C_1 \langle c^2 \rangle = \sqrt{\frac{3kT}{m}}$

$C_2 = \sqrt{\frac{3k(\frac{1}{3})}{\frac{1}{2}m}}$

$\frac{C_1}{C_2} = \frac{\sqrt{\frac{3kT}{m}}}{\sqrt{2k}}$ $\frac{3kT}{m} \times \frac{\frac{1}{2}m}{k}$

$= \sqrt{\frac{3}{2}}$

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	μ_0	$= 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	ϵ_0	$= 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$ $\approx (1/(36\pi)) \times 10^{-9}\ \mathrm{F\,m^{-1}}$
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	$= 9.81\ \mathrm{m\,s^{-2}}$

$2.4 \times 10^3 = \sqrt{\frac{2(6.67\times10^{-11})M}{R_m}}$

$\frac{1}{2}mv^2 = \frac{GMm}{R_m^2}$ $\quad 5760000 = \frac{2(6.67\times10^{-11})m}{R_m}$

$v^2 = \sqrt{\frac{GMm}{R_2}}$

$R_m = 2.316\times10^{-17} m$

$V_e = \frac{1}{2}mv^2 = \frac{GMm}{R_m^2}$. 2.4

$\frac{1}{2}mv^2 = \sqrt{G}$

$v^2 = \frac{2GM}{R_m^2}$ $\quad \cancel{2400}$ $\quad 5760000 = \frac{2(6.67\times10^{-11})M}{R_m^2}$

2.5 ns

$V = \sqrt{\frac{2GM}{R_m^2}}$ $\quad R_m = 2.316\times10^{-17} m$

$f = \frac{1}{T}$

$V_e = \frac{2(6.67\times10^{-11})M}{\sqrt{(1.3)(2.316\times10^{-17})M}}$

700 nm $\quad \lambda = 700$ nm

$v = f\lambda$

No. of λ =

$= 4.43 \times 10^6$

Formulae

	$v = u + at$ sin cos tan
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,	$\phi = -Gm/r$ $\frac{GMm}{r}$
refractive index,	$n = 1/\sin C$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = Q/4\pi\epsilon_0 r$
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,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$
critical density of matter in the Universe,	$\rho_0 = 3H_0^2/8\pi G$
equation of continuity,	$Av = \text{constant}$
Bernoulli equation (simplified),	$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$
Stokes' law,	$F = Ar\eta v$ $6\pi a\eta v$
Reynolds' number,	$R_e = \rho vr/\eta$
drag force in turbulent flow,	$F = Br^2\rho v^2$

[Turn over

Section A [40 marks]

1. Which line in the table correctly indicates the prefixes micro, nano and pico?

	x 10^{-12}	x 10^{-9}	x 10^{-6}
A	nano	micro	pico
B	micro	pico	nano
C	pico	nano	micro
D	pico	micro	nano

C

2. Separate forces 3 N and 4 N are applied simultaneously, in different directions, to a 2 kg mass. Which of the following **cannot** be the acceleration of the mass?

A 0.2 m s^{-2}
B 1.0 m s^{-2}
C 2.5 m s^{-2}
D 3.0 m s^{-2}

$a = \frac{F}{m}$ $\frac{4}{2} = 2$ $\frac{3}{2} = 1\frac{1}{2}$

A

3. The density of the material of a rectangular block was determined by measuring the mass and linear dimensions of the block. The table shows the results obtained, together with their uncertainties.

Mass = (30.0 ± 0.1) g
Length = (5.00 ± 0.01) cm
Breadth = (2.00 ± 0.01) cm
Height = (1.00 ± 0.01) cm

The density was calculated to be 3.00 g cm^{-3}. What was the uncertainty in this result?

A 0.01 g cm^{-3}
B 0.02 g cm^{-3}
C 0.06 g cm^{-3}
D 0.13 g cm^{-3}

$\rho = \frac{m}{V}$
$= \frac{0.1}{0.01}$

C

4. The e.m.f. of a certain thermocouple with one junction **X** in melting ice and the other **Y** in steam from water boiling at standard pressure is 4.1 mV. With **Y** still in steam, and **X** in a certain boiling liquid, the e.m.f. is 11.4 mV, in the same direction as before. The boiling point of the liquid on the Centigrade scale of the thermocouple thermometer is

A -178 °C
B -36 °C
C 36 °C
D 278 °C

$\frac{11.4 - 4.1}{4.1}$

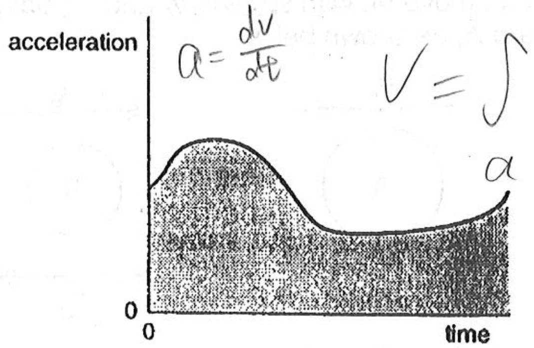
A

$\varepsilon \propto \Delta\theta$

$\frac{4.1 \propto 0 - 100}{11.4 \propto \theta - 100}$

$\theta = -178\ °C$

5. The graph shows how the acceleration of a car is varied over a short time.



$a = \frac{dv}{dt}$ $V = \int a\, dt$

a vs t

B

Over the time shown, which one of **A** to **D** below is represented by the shaded area of the graph?

A change in kinetic energy of the car

B change in velocity of the car

C change in displacement of the car

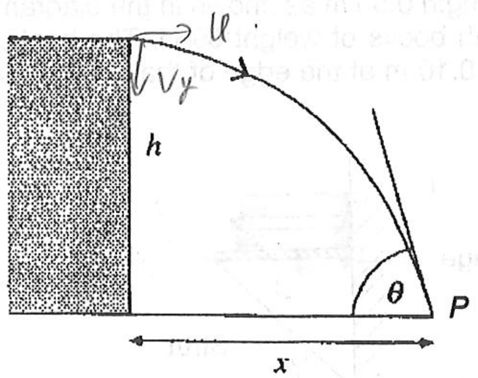
D change in momentum of the car

$v = at$

$s = ut$

$p = mv$

6.



$|\tan\theta| = \left|\frac{V_y}{u}\right|$

$\theta\uparrow$ $V_y\uparrow$

$\tan\theta = \frac{h\uparrow}{x}$

A stone is thrown horizontally with velocity *u* from the top of a vertical cliff of height *h* and enters the sea at a distance *x* from the foot of the cliff at time *t* later. Which of the following is correct?

A The vertical component of acceleration of the stone is greatest at point *P*.

B The distance *x* is given by $x = \frac{ut}{2}$ ut $s = ut + \frac{1}{2}at^2$

C For the same u the higher the cliff the larger is the angle θ

D The speed on reaching the sea depends only on *h*.

C

7. When a firework rocket is fired vertically upwards, it burns some of its contents at a constant rate, producing a constant propulsive force but causing the mass of the rocket to decrease. Which of the following alternatives correctly describes the acceleration of the rocket during the periods *before* and *after* the fuel has been exhausted?
(Air resistance may be neglected.)

$F_v = \text{const}$

mg

$F = F_p - mg$

$a = \frac{F_p}{m} - g$

$a = g$

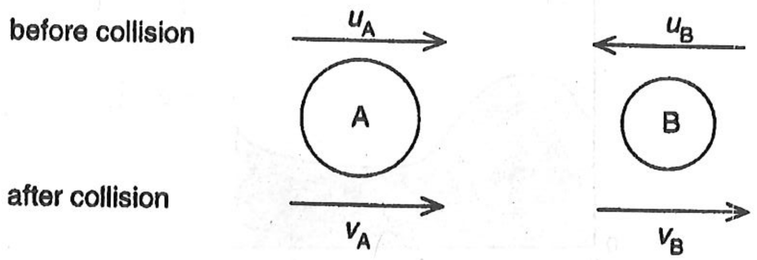
cause $F_p = 0$ when got no fuel

$a = \frac{F}{m}$

	before fuel is exhausted	*after fuel is exhausted*
A	decreasing acceleration	constant deceleration
B	increasing acceleration	decreasing acceleration
C	constant acceleration	constant deceleration
D	increasing acceleration	constant deceleration

D

8. Two spheres **A** and **B** approach each other along the same straight line with speeds u_A and u_B. The spheres collide and move off with speeds v_A and v_B, both in the same direction as the initial direction of sphere **A**, as shown below.



Which equation applies to an elastic collision?

A $u_A + u_B = v_B - v_A$

B $u_A - u_B = v_B - v_A$ ✓

C $u_A - u_B = v_B + v_A$

D $u_A + u_B = v_B + v_A$

$u_A -$

$u_A - u_B = v_A - v_B$

But $u_A - (-u_B) = v_A - v_B$

3y, you suck

A

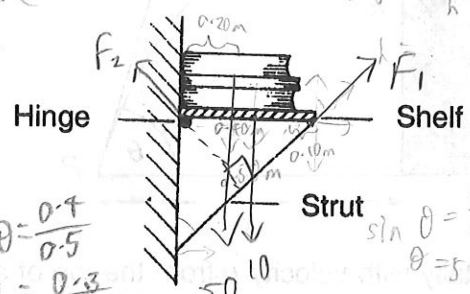
9 **8.** A uniform horizontal shelf of width 0.40 m is attached to a smooth wall by a hinge, and is supported by a strut of length 0.50 m as shown in the diagram below. The shelf weighs 10 N and it is loaded with books of weight 50 N. The books are stacked on the shelf up against the wall to leave 0.10 m at the edge of the shelf clear. What is the compression in the strut?

$50 \times 0.15 + 10 \times 0.2 = N(0.4)$

Taking moment about A,

$F_1(0.4 \sin\theta) = 50 + 0.15 + 10 \times 0.12$

$F_1 = 40$ $\therefore \cos\theta = \frac{0.4}{0.5}$, $\sin\theta = \frac{0.3}{0.5}$



$\cos\theta = \frac{23.15}{h}$

$\sin\theta = \frac{0.4}{0.5}$

$\theta = 53.13°$

60N

$50 \times 0.15 + 10 \times 0.20$

$= N \cos 53.15°$

$= 9.5 Nm = N \cos 53.15$

A 24 N **B** 31 N **C** 40 N **D** 60 N

C

10. A force of 1000 N is needed to lift the hook of a crane at a steady velocity. The crane is then used to lift a load of mass 1000 kg at a velocity of 0.50 ms^{-1}.
How much of the power developed by the motor of the crane is used in lifting the hook and the load? [Take g as 10 ms^{-2}]

A 5.0 kW **B** 5.5 kW ✓ **C** 20 kW **D** 22 kW

10810N

10810N

1000 kg

B

11. A pendulum is swung in such a way that it performs uniform circular motion as shown. Which of the following statements about the motion is correct?

A The linear momentum of the bob is conserved because there is no net force acting on it.
B The bob is in equilibrium because the tension in the string balances its weight.
C The kinetic energy of the bob is constant because no work is done on it.
D The acceleration is constant because the tension is constant.

C

12. The escape speed (i.e. the speed which a body must have in order to escape to an infinite distance from the Moon) of a space shuttle at the Moon's surface is 2.4×10^3 m s^{-1}. What is the escape speed, in m s^{-1}, at a height 0.3 R_m above the Moon's surface, where R_m is the radius of the Moon?

$V = \sqrt{\frac{GM}{R+0.3R}}$

A	1000	**B**	2100	**C**	3200	**D**	4300

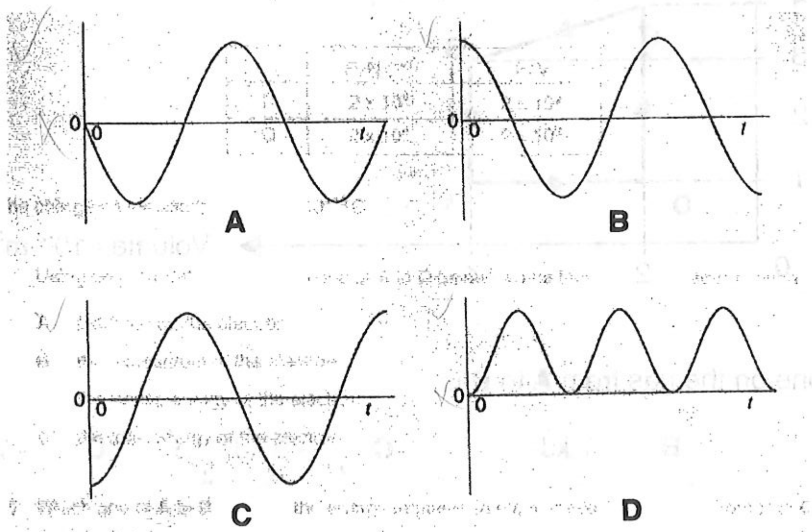
B

13. Data transmitted along glass-fibre cables is in the form of pulses of monochromatic red light each of duration 2.5 ns. Which of the following is the best estimate of the number of wavelengths in each pulse?

A	10^3	**B**	10^6	**C**	10^9	**D**	10^{12}

B

14. The following graphs relate to a mass oscillating in simple harmonic motion. The displacement of the mass from its equilibrium position is a maximum at t = 0. Which one of the following graphs shown below is a graph of velocity of the mass against time ?



A

15. Using a diffraction grating with monochromatic light of wavelength 500 nm incident normally, a student found the 2nd order diffracted maxima in a direction at 30° to the central bright fringe. What is the number of lines per metre on the grating?

A	2×10^4	**B**	2×10^5	**C**	4×10^5	**D**	5×10^5

$d \sin\theta = n\lambda$

$d = \frac{2(500 \times 10^{-9})}{\sin 30°}$

D

16. A gas with molecular mass of M at a thermodynamic temperature T has a root mean square speed of c_1. Another gas with half the molecular mass and at one-third the temperature has a root-mean-square speed of c_2. What is the ratio of c_1 to c_2?

A $\sqrt{\frac{1}{6}}$ **B** $\sqrt{\frac{2}{3}}$ **C** $\sqrt{\frac{3}{2}}$ **D** $\sqrt{6}$

C

17. The average translational kinetic energy of the molecules of an ideal gas in a closed, rigid container is trebled (increase by a factor of three). The pressure of the gas is now

A one-third of the original pressure
B the same as before
C twice that of the original pressure
D three times that of the original pressure

D

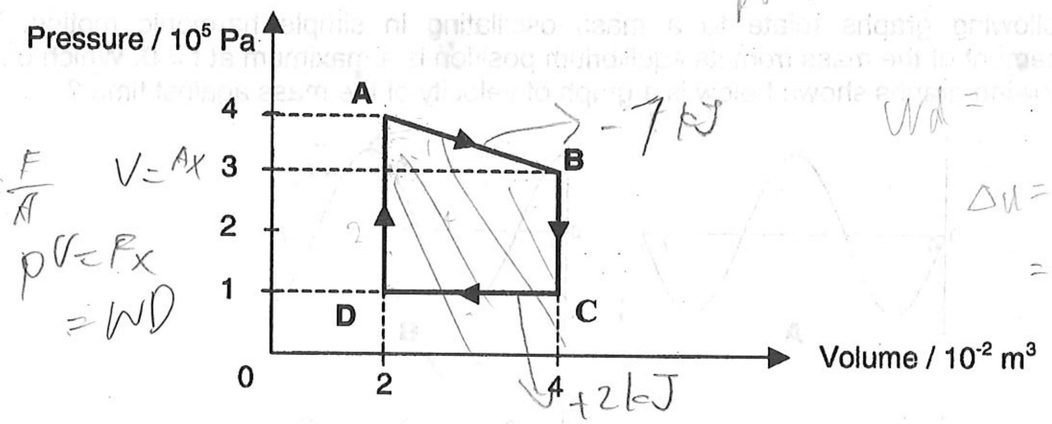
18. 30 cm^3 of water at a temperature of 10°C is added into a styrofoam cup containing 20 cm^3 of water at a temperature of 80°C. Assuming that the heat lost to the surrounding is negligible, the temperature of the water in the beaker, after mixing is

A 38°C **B** 47°C **C** 52°C **D** 61°C

A

Questions 19 and 20 refer to the following information.

A fixed mass of ideal monatomic gas is made to undergo the cycle of changes as shown in the graph below.



19. The work done on the gas from **A** to **B** is

A 5 kJ **B** 7 kJ **C** - 5 kJ **D** - 7 kJ

D

20. The total amount of heat supplied to the system in taking it from **A** → **B** → **C** → **D**→**A** is

A + 5 kJ **B** - 5 kJ **C** + 7 kJ **D** -7 kJ

A

$\Delta U = 0$
$q = -W$
$= -(-5)$
$= +5$