UNIVERSITY OF KWAZULU-NATAL
SUPPLEMENTARY EXAMINATION: 12 January 2009
Subject, Course and Code: Physics Foundation PHYS099 and PHYS199
DURATION: 3 HOURS — TOTAL MARKS:180
INTERNAL EXAMINERS: Ms W. Dlamini, Mrs S. Halstead, Ms A. Marais, Mr R. Webber and Mr E. Zhandire
EXTERNAL EXAMINER: Dr V. Couling

ANSWER ALL QUESTIONS ON THIS PAPER
IN THEIR OWN INTERESTS STUDENTS ARE REQUESTED TO WRITE LEGIBLY.
THIS PAPER CONSISTS OF 12 PAGES. PLEASE SEE THAT YOU HAVE THEM ALL.

Properties of Matter
Question 1 (14 marks)
Give your answers to the following questions with the correct number of significant figures or decimal places.

(a) Calculate the mass of 98 identical pieces of copper if the mass of each piece is 0.0508 kg.
exactly 98 × 0.0508 = 4.98 kg ✓ 3 sig figs ✓ (2)

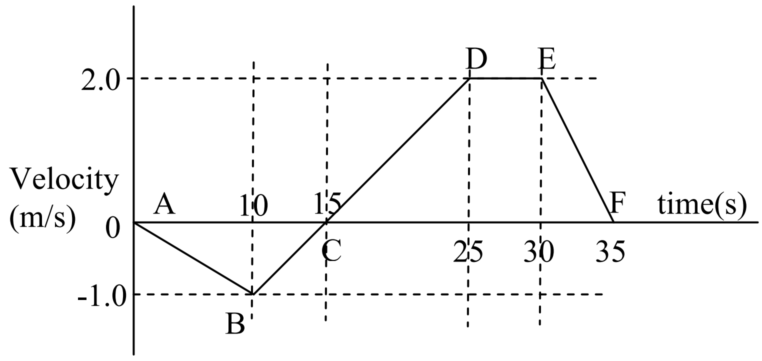
(b) 1.05 m + 1005 cm – 1050 mm (2)
1.05 m + 10.05 m – 1.050 m = 10.05 m ✓ dec. places ✓

(c) 120.5 km/h = *120.5 × 1000/3600 = 33.47* m/s ✓ *4 sig figs* ✓ (2)

(d) (11.06 ± 0.05) cm - (90.5 ± 0.3) mm (3)
= (11.06 - 9.05) ± 0.08 cm = 2.01 ✓ ± 0.08 ✓ cm dec places ✓

(e) A room is 16.40 m long by 4.5 m wide by 3.26 m high. The density of air is 1.29 kg/m^3. Find the mass of the air contained in the room. (5)
V = 16.40 × 4.5 m × 3.26 m ✓ = 240 m^3 ✓
m = D×V = 1.29 × 240 ✓ = 3.1 x 10^2 kg ✓ 2 sig figs ✓

Kinematics Question 2 (9 marks)
The following velocity-time graph represents the movement of a car that was **initially travelling towards the East.**



(a) At which stage(s) did the car have a constant velocity ? *DE* ✓ (1)

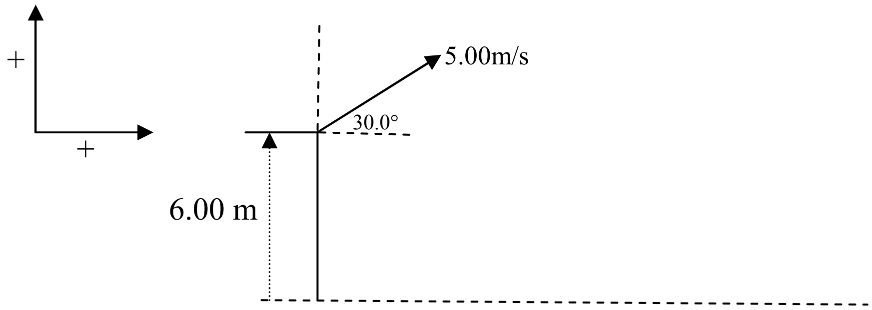
(b) Use the graph to calculate the acceleration from E to F. (3)
$$a = \frac{0-2}{35-30} = -0.4\ ms^{-2}$$ ✓✓✓

(c) Use the graph to determine the displacement of the car between A and C. (3)
s = area under v-t graph = $\frac{1}{2}(15)(-1) = -7.5$ *m* ✓✓✓

(d) Describe the motion of the car from B to C. *Slowing ✓ down in Easterly ✓ direction* (2)

Question 3 (13 marks)

A man throws a brick upwards at an angle of 30.0° to the horizontal at a speed of 5.00 ms^{-1} from the top of a building 6.00 m above the ground, as shown in the diagram below. Taking upwards as positive and the magnitude of g = 9.80 ms^{-2} calculate, to the correct number of significant figures:



(a) the magnitude and direction of the ball's vertical velocity as it reaches the ground. (5)

$v^2 = u^2 + 2as = (25)^2 + 2(-9.8)(-6) = 124$ *therefore* $v = -11.1\ ms^{-1}$

(b) the time taken for the ball to reach the ground (4)

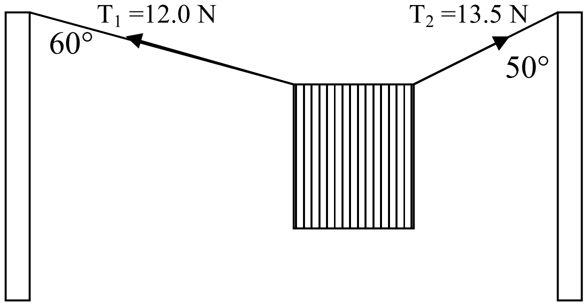
$v = u + at \quad -11.1 = 2.5 + (-9.8)t$ *therefore* $t = 1.39\ s$

(c) How far from the base of the building, in the horizontal direction, does the ball land? (4)

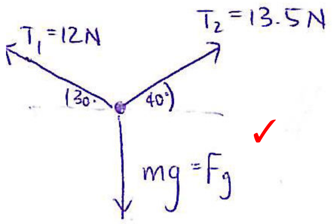
$s = ut + \frac{1}{2}at^2 = (4.33)(1.39) + 0 = 6.02\ m$

Question 4 (11 marks)

A towel is held on an inextensible washing line, as shown alongside. The tensions T_1 and T_2 are 12 N and 13.5 N respectively.
Take the magnitude of $g = 9.80\ ms^{-2}$



(a) Calculate the mass of the towel. (6)



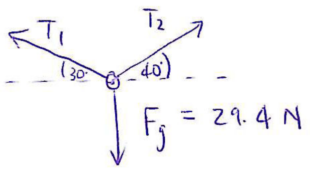
$\sum F_y = T_1 \sin\theta_1 + T_2 \sin\theta_2 - mg = 0$ ✓

$\therefore m = \dfrac{12\sin 30 + 13.5\sin 40}{9.8}$ ✓m

$= 1,5\ kg$ ✓✓

(b) The cord of the washing line has a maximum tensile strength of 25N. Suppose the mass of the towel doubles when it is wet, and all angles remain the same. Will the cord be able to support the weight of the wet towel if it is hung in the same position? (The maximum tensile strength of the cord is the maximum amount of tension the cord can support without breaking.) (5)

5.2 $m_{wet} = 3,0\ kg$.



$\sum F_x = -T_1 \cos 30 + T_2 \cos 40 = 0$

$\therefore T_1 = \dfrac{T_2 \cos 40}{\cos 30} = 0,9\,T_2$ ✓

$\sum F_y = T_1 \sin 30 + T_2 \sin 40 - F_g = 0$

$\therefore T_2 = \dfrac{29.4 - \frac{T_1}{2}}{\sin 40} = 45,7 - 1,3\,T_1$ ✓

$\therefore T_2 = 45.7 - 1,3\,(0.9\,T_2)$

$\therefore T_2 = 21,1\ N$ ✓ and $T_2 > T_1$

$\therefore$ IT WILL NOT BREAK ✓✓

(5)

Question 5 Astronomy (5 marks)

Next to the term in column A, write the letter of the term in column B, which best describes it.

Column A				**Column B**
Planets	*(c)*	*move around a sun*	a)	A satellite
Proxima Centauri	*(e)*	*Produce light or (d) Star*	b)	Galaxy
Sun	*(e)*	*Produce light or (d) Star*	c)	Move around a sun
Moon	*(a)*	*a satellite*	d)	Star
Milky Way	*(b)*	*Galaxy*	e)	Produces light

Electrostatics Take the electrostatic constant k = 9.00 x 10^9 NmC^{-2}

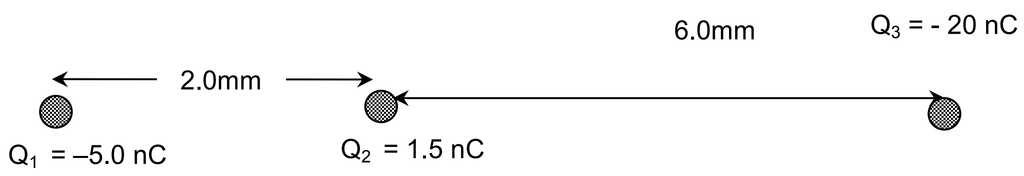
Question 6 (30 marks)

(a) Two charged objects have a repulsive force of 0.0980 N. If the distance between the two charges is doubled, then what is the new force? (3)

$\mathbf{F} \propto \frac{1}{\mathbf{r}^2}$ ✓= 0.0980 N

$F_{new} = \frac{1}{(2r)^2} = \frac{1}{4} x0.0980$ ✓= 0.0245 N✓

(b) Three charges Q_1, Q_2 and Q_3 with positions shown in the diagram exert electrostatic forces on each other.



(ii) Determine the magnitude and direction of the resultant electrostatic force on Q_2. (11)

Formula ✓

$F_{12} = 9\times10^9 \frac{|-5.0\times10^{-9} \times 1.5\times10^{-9}|}{(0.002)^2} = 1.69\times10^{-2}$ N ✓✓ *Left* ✓

$F_{32} = 9\times10^9 \frac{|-20\times10^{-9} \times 15\times10^{-9}|}{(0.006)^2} = 7.5\times10^{-3}$ N ✓✓ *Right* ✓

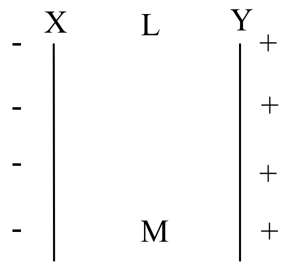
$F_{resQ2} = 9.4 \times 10^{-3}$ N ✓left✓

(ii) Determine the magnitude and direction of the electric field at the point where Q_2 is situated. (4)

$E = \frac{\mathbf{F}}{\mathbf{q}} = \frac{9.4\times10^{-3}}{1.5\times10^{-9}}$ = 6.3 x 10^6 N/C left✓✓ ✓ ✓

(c) Two parallel charged plates, X and Y, are placed as shown in the diagram.

(i) If a positive charge is moved/moves horizontally from Y to X, what energy changes take place? *gain E_K lose E_P* (2)



(ii) If a positive charge is moved/moves vertically from L to M, what energy changes take place? *none* (1)

(d) A charge Q of 4.0 μC exerts a force of 3.0 x 10^{-2} N to the right, on a charge q of 2.0 nC. Calculate:

(i) The electric field at q (4)

$$E = \frac{F}{q} = \frac{3.0x10^{-2}}{2.0x10^{-9}} = 1.5x10^{7}\ N/C\ right$$

(ii) The distance between the charges (5)

$$R^2 = \frac{kQq}{F} = \frac{9x10^{9}x4.0x10^{-6}x2.0x10^{-9}}{3.0x10^{-2}} = 0.0024$$

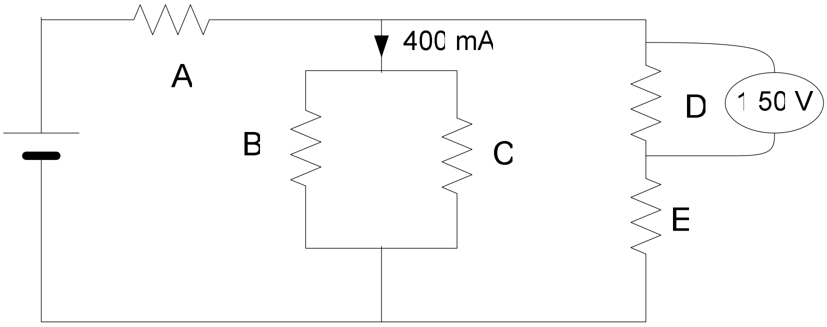
$r = 4.9x10^{-2} m$

OR USE $r^2 = \frac{kQ}{E}$

Electric circuits

Question 7 (21 marks)

The following circuit has **identical resistors each of resistance R**. The battery and connecting leads have no resistance. There is a current of 400 mA as shown in the diagram, and the voltage across resistor D is 1.50 V.



(a) What is the current through:

$I_C = \frac{400\text{mA}}{2} = 200\text{mA}$

(i) Resistor C? (1)

$I_D = \frac{400\text{ mA}}{4} = 100\text{ mA}$

(ii) Resistor D? (3)

$I_A = I_D + 400\text{mA}$

$= 100 + 400 = 500\text{mA}$

(iii)Resistor A? (2)

(b) Calculate amount of charge that flows through resistor E in 20 s. (3)

√ √ √

Q = I x t = 0.100 x 20 = 2.0 C

(c) Calculate

(i) The voltage across resistor C

$V_C = V_D + V_E$

$= 1.50 + 1.50 = 3.00\text{ V}$

(3)

(ii) The voltage across resistor A. (3)

✓ ✓ ✓

$V_A = (I_A/I_D) \times V_D = (500/100)\times 1.5 = 7.5\text{V}$

(iii)The battery voltage (3)

$V_{battery} = V_A + V_{parallel} = 7.50 + 3.00 = 10.50\text{ V}$

$R = \frac{V_D}{I_D} = \frac{1.5}{100\times 10^{-3}} = 15\ \Omega$

(iv) The resistance R of one resistor. (3)

Question 8 (6 marks)

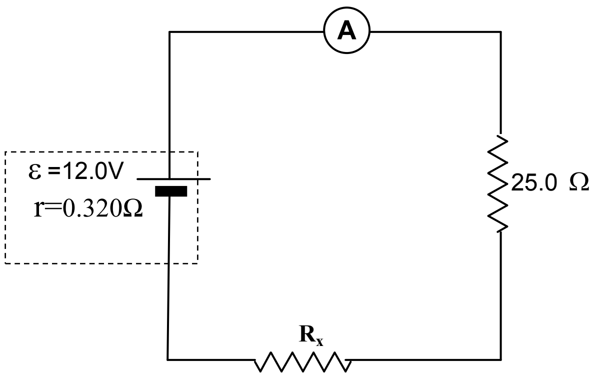
Hlonophile has R1.05 credit on her pre-paid electricity meter. Electricity cost 50c per unit of kilowatt-hour. She gets home, cooks supper before dark using a 2000W stove for 50 minutes, then studies, using the 100 W bulb. How long will she be able to study? Show calculations to support your answer. (6)

"units" of energy left $= \frac{1.05}{0.50}$ *= 2.1 kWh*✓

Stove: $W = \frac{2kW x 50 hr}{60}$ ✓✓*= 1.67 kW h therefore 2.1 – 1.67 = 0.43 kWh left for light* ✓

Time with light bulb: $t = \frac{0.43}{0.100}$ ✓*= 4.3 hours. Therefore she can study for 4.3 hrs*✓

Question 9 (10 marks)



The diagram above shows an electrical circuit consists of an unknown resistor Rx connected in series with a 25.0 Ω resistor to a battery of emf of 12.0 V and internal resistance of 0.320 Ω. An ammeter connected in the circuit reads 200 mA.

(a) A voltmeter is connected across the battery when the circuit is closed. What is its reading? (3)

its reading?

$12.0 = V_{tpd} + \text{lost Volts} = V_{tpd} + 200\times10^{-3}(0.320)$ ✓ ✓

$V_{tpd} = 11.9\,V$ ✓

(b) Calculate the value of the unknown resistor R_x. (4)

$V_{tpd} = I(R_x + 25)$ ✓ $\Rightarrow R_x = \frac{11.9}{200\times10^{-3}} - 25$ ✓

$R_x = 34.5\,\Omega$ ✓

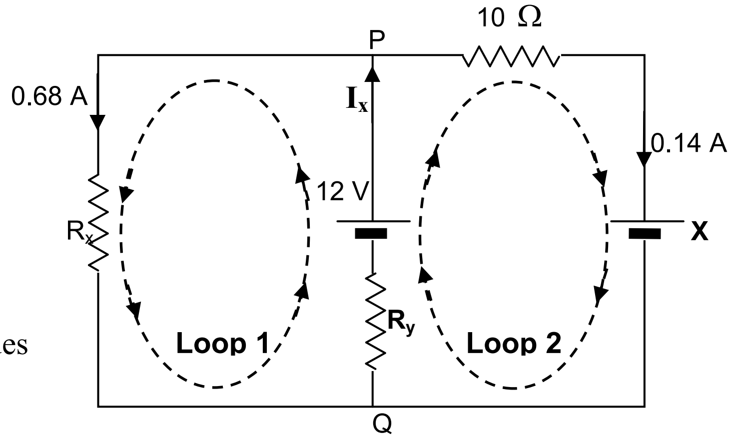
(c) The rate at which energy is used by the 25.0 Ω resistor. (3)

$P = I^2 R$ ✓

$= (200\times10^{-3})^2(25.0)$ ✓

$= 1.0\,W$ ✓

Question 10 (8 marks)



In the circuit shown above the unknown resistances R_x and R_y are equal. Use the nodes and loops marked to find:

Subtract ½ for missing loop or law in each!

(a) Current, I_x - At node P or Q, using Kirch I : (2)

$I_x = 0,68 + 0,14$
$= 0.82$ A

(b) Resistance, R_x In loop1, using Kirch II : (3)

loop1: $12 = R_x(0,68) + R_y I_x$ ✓
$R_x = R_y$
$12 = 0,68 R_x + 0,82 R_x$
$R_x = 8.0\ \Omega$ ✓

(c) Battery voltage, V_x In loop 2, using Kirch II (3)

loop2: $12 - V_x$ ✓ $= 10(0,14) + R_y I_x$ ✓
$R_y = R_x$
$\Rightarrow -V_x = 1.4 + 8,0(0.82) - 12$
$V_x = 4.0V$ ✓

(d) Newton's Laws

Question 11 (7 marks)

An astronaut lands on a spherical (round) planet, X, of radius 150 km. She finds that a 2.0 kg mass released from rest at a height of 1.0 m takes 1.5 s to reach the surface.

Take G = 6.67 x 10^{-11} Nm^{2}kg^{-2} Calculate:

(a) The gravitational acceleration of the object on planet X. (3)

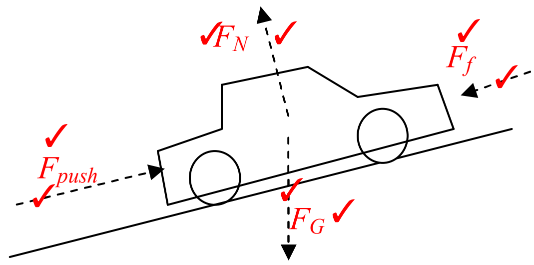
3.1 $u = 0$
$s = 1,0$ m $\therefore a = \frac{2s}{t^2}$ ✓ $= 0,9\ m/s^2$ ✓✓ $= g_{planet\ x}$
$t = 1,5$ s

(b) The mass of planet X. (4)

$g = G\frac{M}{r^2} \therefore M = \frac{gr^2}{G}$ ✓ $= \frac{0.9 \times (150\ 000)^2}{6,67\times10^{-11}}$ ✓ $= 3,0\times10^{20}$ kg ✓✓

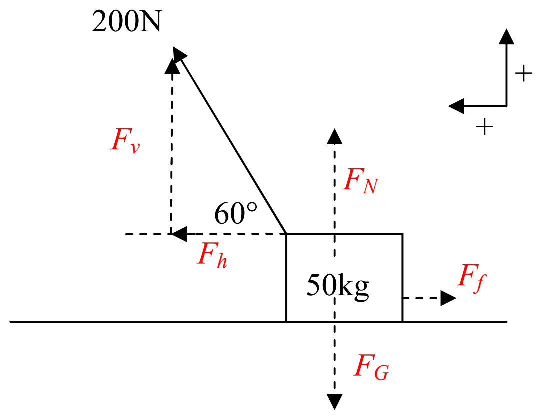
Question 12 (8 marks)

On the diagram alongside, draw in, and label all the forces acting on the car as it is being pushed up the hill at a constant velocity. Show approximate magnitudes. (8)



Question 13 (9 marks)

A box is being dragged along a rough concrete floor, as shown in the diagram. The mass of the box is 50 kg and the force exerted by the rope is 200 N, and the force of friction is 25 N. Take "up" and "left" to be positive as shown in the diagram alongside. Determine:



(a) The normal force acting on the box (4)

$F_v = 200\sin 60° = 173$ N ✓ and $F_R = 0$ ✓

$F_v + F_N + F_G = 0$ ✓ $F_N = 490 - 173 = 317$ N ✓

(b) The acceleration of the box (5)

$F_h = 200\cos 60° = 100$ N ✓✓ $F_R = 100 - 25 = 50a$ ✓✓ $a = 1.5\ ms^{-2}$ ✓

Question 14 (8 marks)

Determine the breaking force needed to bring a small truck of mass 2000 kg travelling **west** at 120 km/h to a stop in 100 m. (8)

$\mathbf{u} = \frac{120 \times 1000}{3600} = 33.3\ \mathbf{m/s}$ ✓ $v^2 = u^2 - 2as$ ✓ so: $0 = 33.3^2 - 2a(100)$ ✓✓

$\mathbf{a} = \frac{0 - 33.3^2}{2 \times 100} = -5.56\ m/s^2$ ✓

$F_{res} = m.a = 2000 \times (-5.56)$ ✓ $= -$✓1.11×10^3 N✓

Optics

Question 15 (21 marks)

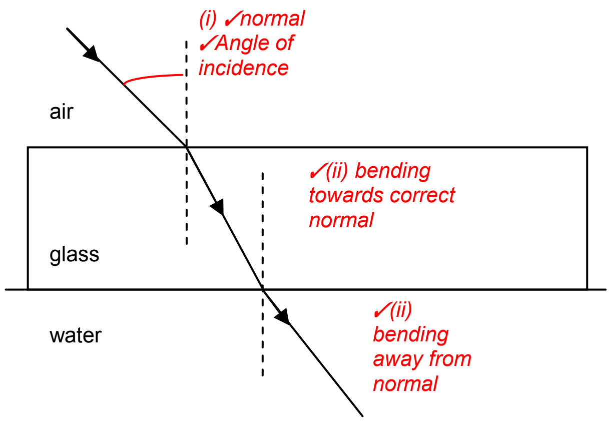
material	refractive index
air	1.00
ice	1.31
water	1.33
perspex	1.42
glass	1.58

(a) The diagram below shows light entering a glass block which is placed above some water. Use the table of refractive indices to answer these questions. Please use a ruler, and show angles that are approximately correct, you do not need to calculate them.

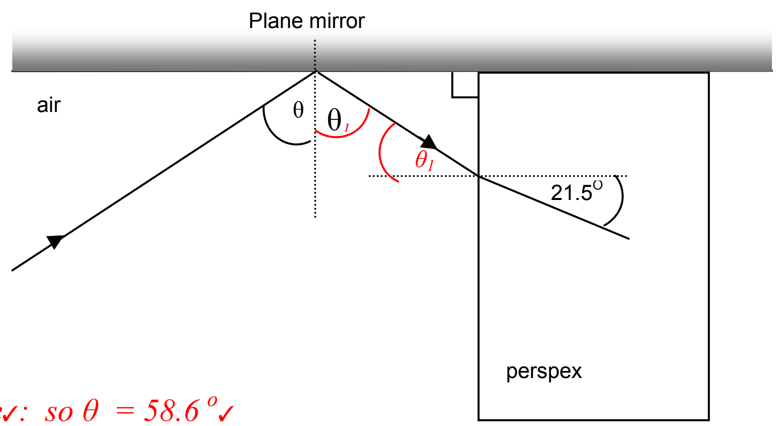
On the diagram

(i) Mark in the angle of incidence. (1)

(ii) Show the path of the light right through into the water. (3)



(b) The surfaces of a plane mirror and a rectangular block of Perspex are at right angles to each other as shown in the diagram below. The angle of refraction of a light ray is measured as 21.5° in the Perspex. Calculate the angle of incidence of the light ray, θ, at the surface of the mirror. Explain your reasoning at each stage. (6)



Refraction into Perspex:

$n_{air} \sin\theta_{air} = n_{Perspex} \sin\theta_{perspex}$ ✓

$1.00 \times \sin\theta_2 = 1.42 \sin 21.5^o$ ✓✓

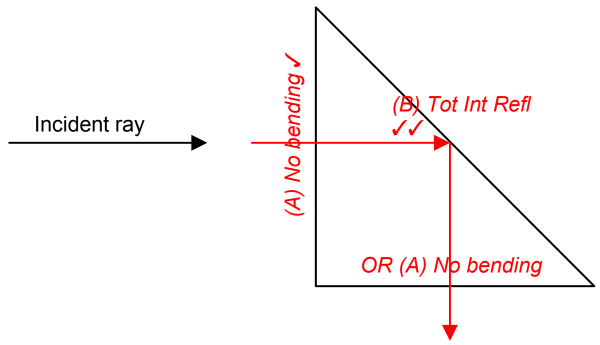
$\theta_2 = 31.4^o$ ✓

The two normals are perpendicular

so $\theta_1 + \theta_2 = 90^o$ *and* $\theta_1 = 58.6^o$

But angle of reflection = angle of incidence✓*: so* $\theta = 58.6^o$ ✓

(c) A periscope makes use of total internal reflection. It uses a triangular glass prism such as shown in the diagram below. Use the data from the table on the previous page to help answer these questions.



(i) **On the diagram above** label clearly
(A) At least one surface where no bending of the light ray takes place. (1)

(B) At least one place where total internal reflection will take place. (2)

(ii) Calculate the critical angle for glass. (3)

Critical angle is θ_i for $\theta_r = 90^o$ and incident in more optically dense medium

Therefore $n_{glass} \sin \theta_{Cglass} = n_{air} \sin 90^0$ ✓ *gives:* $\sin \theta_{Cglass} = \dfrac{1}{1.58}$ ✓

so $\theta_{Cglass} = 39.3^o$ ✓

(iii) If the prism in the diagram were made of ice, would the periscope work? Explain by means of a calculation. (5)

Critical angle for ice: $\sin \theta_{Cice} = \dfrac{1}{1.31}$ ✓ *so* $\theta_{Cice} = 49.8^o$ ✓ *The geometry of the prism makes* $\theta_{ice} = 45^o$ ✓ . *When θ_i is less than the critical angle, then total internal reflection does not occur,* ✓ *the prism will only reflect partially and not work as effeciently.* ✓

TOTAL MARKS 180