JOHN RAPP.

447 3041

Anything from 2-4 sig. figures. Section A: deduct 4 (max
5 N instead of 5·00N - accept it. Section B: deduct 2 (max

UNITS - very important Section A - take 1 off. (max. 4)
Section B - be a little lenient. (max. of 3).

Curtin University of Technology

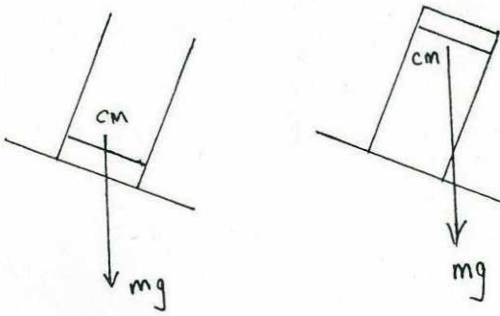
DEPARTMENT OF APPLIED PHYSICS

TEE EXAMINATION 1990 DRAFT SOLUTIONS

SECTION A:

NO REFERENCE TO DIAGRAM BUT CORRECT - 1 MARK OFF.

A1.



Because of the heavy base, the centre of mass is close to the base.

(1 mark)

When the glass is placed top down, the vertical line from the centre of mass passes outside the rim of the glass, so it is unstable.

(1 mark)

Can be explained verbally - must refer to the diagram.

Construction lines on diagram - 2 marks

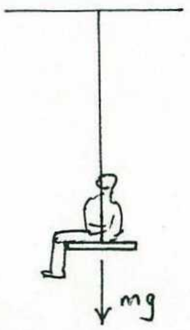
A2. The device depends on the principle that the torque increases when the force is applied further from the axis of rotation.

Some statement about increased grip / friction - max. 2 marks. (2 marks)

On the diagram, the torque will be greater when the force is applied at the ends of the device's arms rather than at the circumference of the tap.

Statement of "principle of moments" - 1 marks only. (2 marks)

A3.



a negative - 1 mark off.

The total tension in the ropes is given by

$$T = mg + mv^2/r$$

(2 marks)

where m = mass(child) + mass(swing)

$$T = 40 \times 9.8 + 40 \times 2.4^2 / 2.8$$
$$= 474 \text{ N}$$ (1 mark)

Thus the force on each rope is 237 N (1 mark)

centripetal force.

(Award $\overset{2}{3}$ marks if the force due to gravity is omitted), forgetting 1 of the masses

---

A4. The force exerted on a mass m a distance d from the centre of the earth is

$$F = G M m / d^2$$

1 mark.

where $d = R_E + 2.50 \times 10^5$ m (2 marks)

2 MARKS OFF IF HEIGHT IS NOT CONSIDERED.

i.e. $mg = GMm/d^2$ (1 mark)

$$g = 6.67 \times 10^{-11} \times 5.98 \times 10^{24} / (6.37 \times 10^6 + 2.5 \times 10^5)^2$$

$$= 9.10 \text{ ms}^{-2}$$ (1 mark)

By ratio, the answer is 9·07 ms^{-2}.

CENTRIFUGAL FORCE BALANCING CENTRIPETAL FORCE O.K.

A5. An astronaut in orbit around the earth has no reaction force exerted on him so feels weightless. He is being accelerated due to the gravitational force, but this is providing centripetal acceleration and so can not be perceived.

(4 marks)

Mentioning "free-fall" – 2 marks only. MUST MENTION REACTION FORCE FOR FULL MARKS

A6. The phenomenon is resonance. (1 mark)

The sound waves from the cough have the same frequency as the natural frequency of vibration as the piano strings. These strings are forced into vibration and when the sound from the cough has died away they will continue vibrating at their resonance frequency and so can be heard.

Cough has a limited range of frequencies ⇒ only certain strings resonate. (3 marks)

A7. a) Since the beat frequency increased on tightening the string, the original frequency f must have been higher than that of the tuning fork.

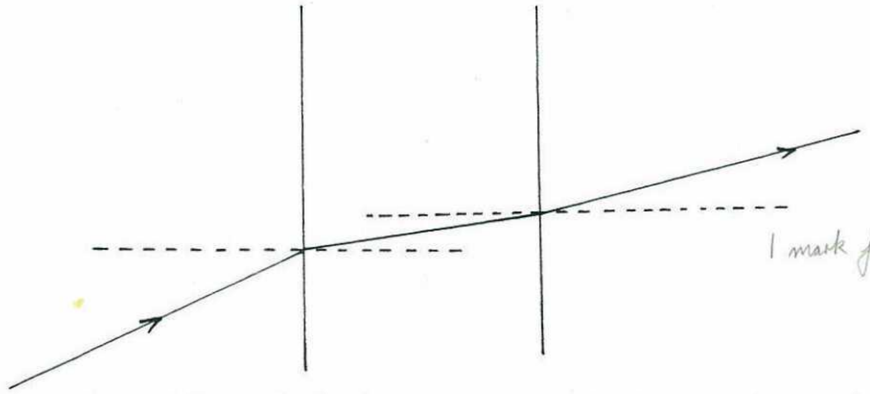
$f = 297 + 4 = 301$ cps (~~2~~ 3 marks)

$297 - 4 = 293$ Hz – 1 MARK

b) The tension on the string will have to be reduced in order to drop the frequency to that of the tuning fork since less tension in the string will reduce its frequency.

(~~2~~ 1 marks)

A8. a)



1 mark for each refraction

(2 marks)

(To obtain full marks it will be necessary for it to be shown clearly on the diagram that the angle of refraction of the emerging ray is less than the angle of incidence of the original ray).

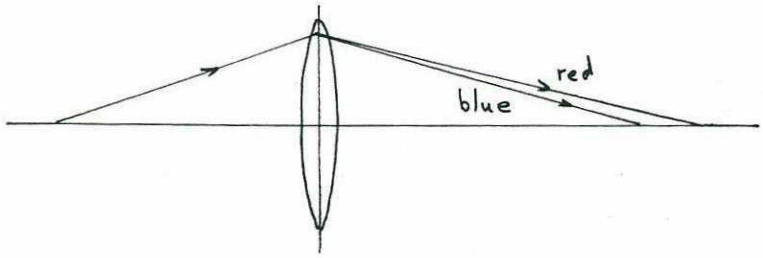
b) As the light passes fron air to glass, its

- velocity **decreases**
- frequency **remains the same**
- wavelength **decreases**

1 off for each mistake. (2 marks)

A9. a) The phenomenon is chromatic aberration (1 mark)

b)



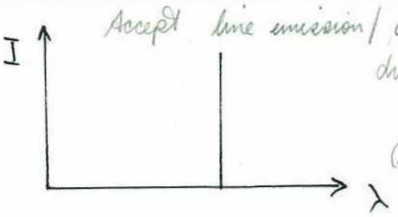
(2 marks)

The diagram shows the red ray comes to a different focal point than the blue ray. (1 mark)

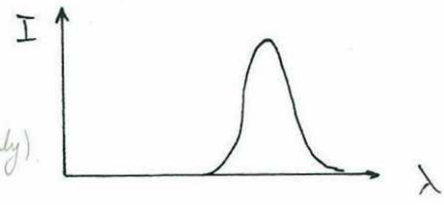
BAND ABSORPTION ?

A10.

Accept line emission / continuous spectrum diagrams. + explanation. (2 marks for diagram only)



sodium lamp



incandescent lamp with filter

(2 marks)

The sketches show that the sodium lamp light consists of a single wavelength whereas the globe has a range of wavelengths centred in the yellow region of the spectrum since yellow paint transmits a range of wavelengths.

(2 marks)

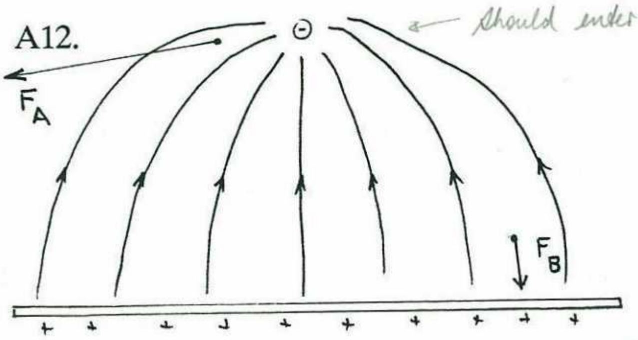
A11. Doubling the charge will increase the force by a factor of 4 (1 mark)

Trebling the distance will reduce the force by a factor of 9 (1 mark)

Hence the resultant force is 4/9 of the original and is equal to 0.0667 N. (2 marks)

1 mark for using Coulomb's Law.

A12.



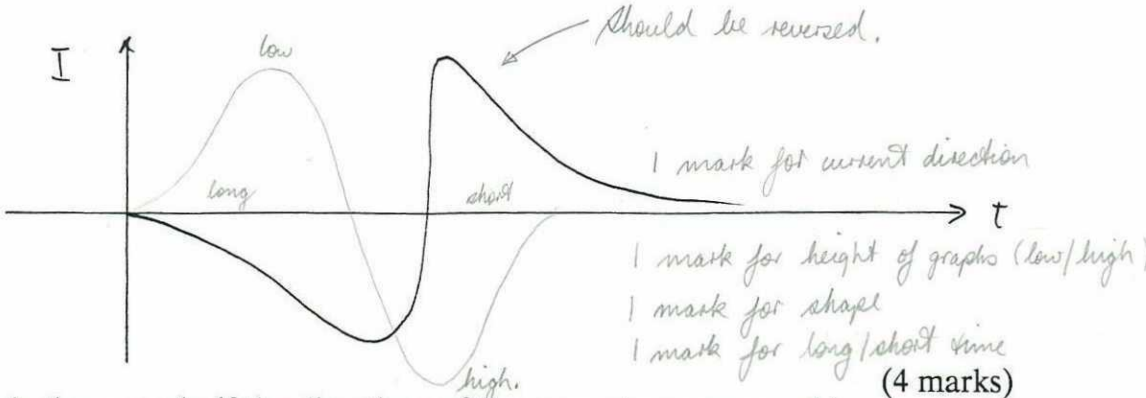
← Should enter and leave at right angles.

Shape of field -- 2 ~~1~~ mark

Forces on the electrons -- 1 ~~2~~ marks

Relative magnitudes of the forces -- 1 mark

A13.



(4 marks)

(Give only three marks if the directions of the currents are reversed.)

A14. The wire will move parallel to the magnet's arms away from the top of the magnet. (away from the magnet)

(2 marks)

This occurs since the current flowing down the wire generates a magnetic field which interacts with the magnetic field of the magnet.
(or the moving charge)

(2 marks)

A15. The energy of the photoelectron is

$$KE = \tfrac{1}{2}mv^2 = \tfrac{1}{2} \times 9.11 \times 10^{-31} \times (1.75 \times 10^6)^2 = 1.395 \times 10^{-18}\ J$$

(1 mark)

The energy of the photon is found by multiplying this figure by 100/60

(1 mark)

The photon energy is given by E = hf so that its frequency is

$$f = E/h = \cancel{2.10}\ 3.51 \times 10^{15} \text{ cps}$$

(2 marks)

2.10×10^{15} Hz WITHOUT USING 100/60.

A16. a) The charge carried by the radiations is:

A: negative
B: none

(2 marks)

b) The particles could be

A: beta particle , electron
B: gamma ray , neutrons

(2 marks)

A17. $${}_{84}Po^{218} \longrightarrow {}_{82}Pb^{214} + {}_{2}He^{4}$$

The particle emitted is an alpha particle

(2 marks)

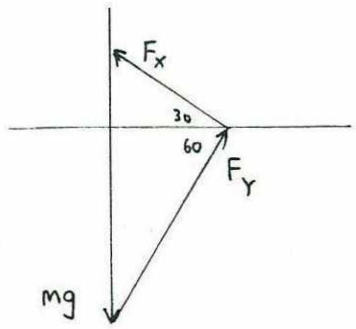
$${}_{82}Pb^{214} \longrightarrow {}_{83}Bi^{214} + {}_{-1}e^{0}$$

The particle emitted is a beta particle

(2 marks)

$mg\cos 60^\circ = 2.45\ N$
½ mark off if incorrect (must use diagram)

A18.



The force is perpendicular to the rail, towards the left

(1 mark)

From the diagram,

$$F_X \sin 30 + F_Y \sin 60 = mg$$

$$F_X \cos 30 + F_Y \cos 60 = 0$$

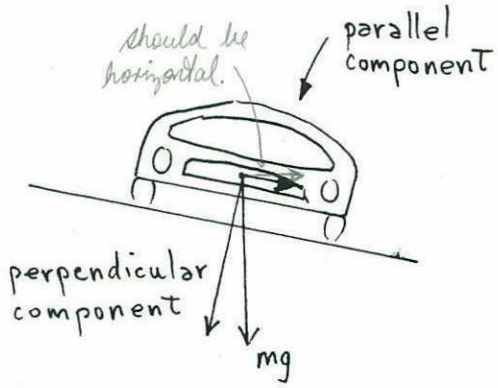
$$F_X \sin 30 + \left(F_X \frac{\cos 30}{\cos 60} \sin 60\right) = mg$$

(2 marks)

$$F_X = \frac{mg}{\sin 30 + \cos 30 \tan 60} = 2.45\ N$$

(1 mark)

A19.



A car going around a corner requires a centripetal force to move it in the circular path. This force is exerted through the tyres.

(2 marks)

The centripetal force is directed towards the centre of the curve. To help provide this, a force is exerted on the tyres parallel to the road surface. If the road is banked, some of this is provided by a component of the gravitational force. Thus less force is exerted on the tyres parallel to the road, which reduces the chances of skidding.

(2 marks)

(Give two marks for the diagram alone)

AVE = 40.75° WITH 37.5° AVE = 41.40° WITHOUT 37.5°

A20. Five of the six results lie between 41.0^{o} and 42.0^{o}, so it would appear that the uncertainty is less than 0.5^{o}. Hence the 37.5^{o} result can be discarded.

2 (~~1~~ mark)

The critical angle is related to the refractive index by

If wrong angle (complementary) angle, n = 1.33 ⇒ no glass.

$$n = \frac{1}{\sin C}, \quad = 1.512 \text{ (SHEET GLASS)}$$

so the refractive indices corresponding to the extreme angles are 1.524 and 1.494.

1 (~~2~~ marks)

Thus the glass should be either ~~dense flint glass~~ or sheet glass.

For not removing 37.5° – answer is alumino-silicate. (2 marks)

(1 mark)

A21. **D**	A23. **C**	A25. ~~**C**~~ B	A27. ~~**C**~~ B	A29. **D**
A22. **C**	A24. **E**	A26. **A**	A28. ~~**C**~~ E	A30. **C**

(1 mark each)

SECTION B

B1. a) The magnification m is given by

$$m = \frac{\text{image size}}{\text{object size}} = \frac{\text{image distance}}{\text{object distance}} = \frac{v}{u}$$

$\therefore\ v = u \times 1500 / 200 = 75\,u$ (1 mark)

Also $v + u = 2000$ mm
so $76\,u = 2000$
$u = 26.3$ mm (2 marks)

V = 2·00m – give 2 marks only!
(becomes 26·3mm for f)

The focal length of the lens can be found from

$$1/f = 1/u + 1/v = 1/1974 + 1/26.3$$

$$\therefore\ f = +26.0 \text{ mm}$$

Thus the type of lens is converging (convex) (1 mark)

b) The focal length of the lens is 26.0 mm 4 MARKS (SEE ABOVE) (1 mark)

c) The lens needs to be 26.3 mm from the slide (1 mark)

d) The function of this lens is to make sure the maximum amount of light from the lamp falls on the slide. (Allocate the mark for a suitable diagram).

(1 mark)

B2. a) Writing ℓ for the distance between the rails and x for the distance along the rails, the induced emf is

$$= (\phi_2 - \phi_1) / (t_2 - t_1) = B(A_2 - A_1) / (t_2 - t_1)$$

$$= B\ell(x_2 - x_1) / (t_2 - t_1) = B\ell v$$

$$= 50 \times 40 \times 10^{-3} \times \cancel{0.25}\ 0{\cdot}0250$$

$$= \cancel{0.500\text{ V}}\ 0{\cdot}0500\text{ V}$$ (2 marks)

b) The current flow is anticlockwise (LONM) since this will produce a force opposing the motion of the wire, as expected by Lenz's law.

(1 mark)

c) The rate of work is given by

$$P = VI = V^2 / R$$

$$= 0.5^2 / 5 = 0.0500 \text{ W} \quad 5{\cdot}00 \times 10^{-4}\text{ W}$$ (2 marks)

d) If the 5 Ω resistor is replaced with a smaller resistor, it can be seen from part c) that the power dissipated in the resistor will increase. Since the power is equal to the rate of work, this will increase correspondingly.

Need only say increase! (1 mark)

1 MARK FOR CONSTANT SPEED IN EACH (HORIZONTALLY)

speed is increased.

B3. a) In diagram i) the electron will be deflected downwards. The amount of force on the electrons depends on the electric field. This force does not affect the horizontal velocity of the electrons. [However, it will increase the vertical velocity and hence the total (vector) velocity increases]. ← Extra information

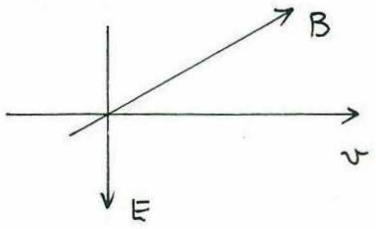
1 mark for each point

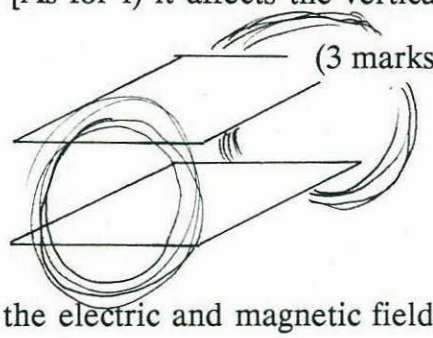
In diagram ii) the electron will be deflected downwards. The force will depend on the velocity of the electron since F = qvB and clearly will depend also on the size of the magnetic field. This force does not affect the horizontal velocity of the electrons. [As for i) it affects the vertical velocity].

speed remains constant.

(3 marks)

b)





(The diagram needs to show clearly that the electric and magnetic fields are perpendicular to one another)

(1 mark)

c) The situation in b) occurs for electrons of only one velocity since the force produced by the magnetic field depends on the velocity, but the force produced by the electric field does not.

(1 mark)

The velocity is found from

$$F = Eq = qvB$$

$$\therefore \quad v = E/B = 1.5 \times 10^4 / 0.3$$

$$= 5.00 \times 10^4 \text{ m s}^{-1}$$ (1 mark)

B4. a) The rate of energy production is given by

$$P = VI = V^2/R$$ (1 mark)

i) On the low setting,

$$P = 250^2 / 2000 = 31.2 \text{ W}$$ (1 mark)

ii) On the high setting the resistors are in parallel so the power will be three times this value or

$$P = 93.7 \text{ W}$$ (93.8) (1 mark)

b) The energy used in 12 hours = $Pt = 93.7 \times 12 \times 3600$ J (1 mark)

One unit is 1 kW-hr = $1000 \times 3600 = 3.6 \times 10^6$ J (1 mark)

Thus the cost of the electricity is

$$\{93.7 \times 12 \times 3600 / (3.6 \times 10^6)\} \times 10.5$$

$$= 11.8 \text{ cents}$$ (1 mark)

B5. a) The nuclear mass defect is the difference between the mass of the nucleus and the mass of the same number of individual protons and neutrons. This provides the energy used to bind the nucleons together.

(1 mark)

b) The binding energy of the helium nucleus is then

1 mark for $E = mc^2$
1 mark for $(\quad)c^2$
1 mark for answer.

$$E = \Delta m\, c^2 = (2m_p + 2m_n - m_{He})\, c^2$$

$$= (2 \times 1.007277 + 2 \times 1.008665 - 4.001509) \times 1.661 \times 10^{-27} \times (3 \times 10^8)^2 \,/\, 1.6 \times 10^{-19}$$

$$= 28.4 \text{ MeV}$$

3 (~~2~~ marks)

Using $m_{He} = 4.001509$ as the atomic mass will result in $2e^-$'s being subtracted. Give full marks.

c) This is consistent with the value on the graph since the graph shows binding energy per nucleon.

(1 mark)

d) Fission is the binding together of light elements to form a heavier element; that is, going from low mass numbers to a higher mass number. Fission is the splitting of a nucleus of high mass number into two portions of lower mass number. Both these processes lead towards elements in the centre of the graph, which have a greater binding energy per nucleon, and as a result energy is produced.

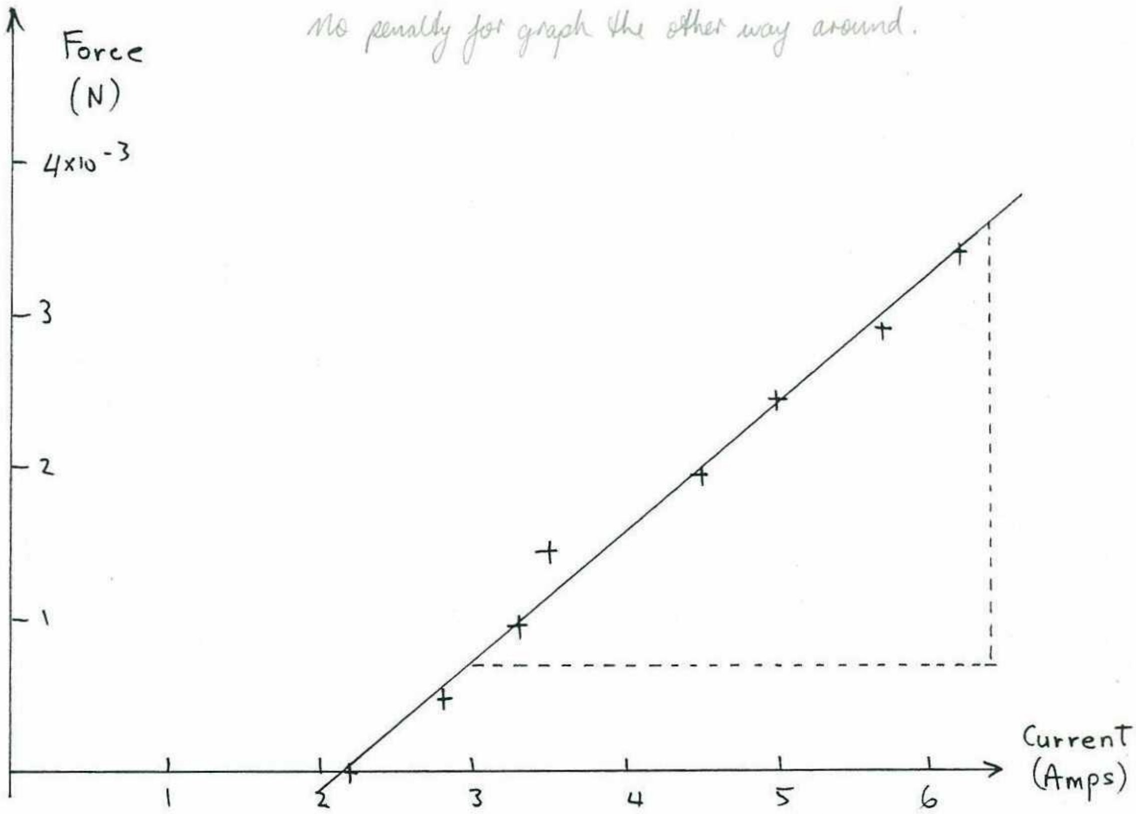
(2 marks)

B6. a)

Mass (mg)	Force (N)
50	0.49×10^{-3}
100	0.98
150	1.47
200	1.96
250	2.45
300	2.94
350	3.43

(1 mark)

b) No penalty for graph the other way around.



Layout, drawing of axes, scaling -- 1 mark
Plotting of points, drawing line of best fit -- 1 mark

c) The graph does not pass through the origin since a certain current is required just to support the mass of the wire.

(1 mark)

d) The slope of the graph is GIVE 1 MARK FOR A SLOPE IF WRONG.

$$m = (3.6 - 0.68) \times 10^{-3} / (6.4 - 3.0) = 8.59 \times 10^{-4}\ \text{N A}^{-1}$$

(1 mark)

The force on the wire is given by $F = i \ell B$. From this it is seen that the slope of the graph is equal to ℓB. Thus

$$B = \text{slope} / \ell = 8.59 \times 10^{-4} / 25 \times 10^{-3}$$

Be liberal $= 0.0343$ T (latitude due to line of best fit) (2 marks)

B7. a) Since the wheat falls through 1.75 m, its velocity the instant it hits the belt can be found from

$$v^2 = u^2 + 2as = 0.2^2 + 2 \times 9.8 \times 1.75$$

$$v = 5.86 \text{ m s}^{-1}$$

The rate of change of the vertical component of the momentum is therefore

$$(5.86 - 0.0) \text{ m s}^{-1} \times 10 \text{ kg s}^{-1} = 58.6 \text{ kg m s}^{-2}$$

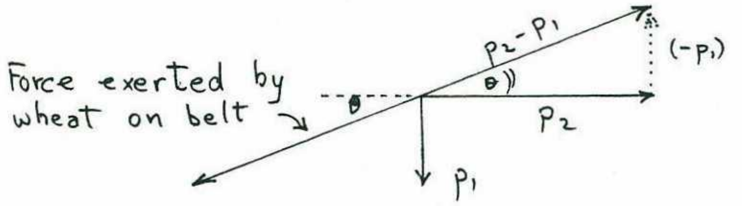
(2 marks)

b) Similarly, the rate of change of the horizontal component of the momentum is

$$(1.25 - 0) \text{ m s}^{-1} \times 10 \text{ kg s}^{-1} = 12.5 \text{ kg m s}^{-2}$$

(1 mark)

c) If p_1 is the initial momentum and p_2 is the final momentum, the change in momentum can be found from the vector triangle :



← 1 mark.

It can be seen that the net rate of change in the momentum is

$$\sqrt{(58.6^2 + 12.5^2)} = 59.9 \text{ kg m s}^{-2}$$ ← 1 mark

According to Newton, the force is equal to the rate of change of momentum so the force is 59.9 N.

(2 marks)

The direction of the force exerted by the wheat on the belt is found by looking at the diagram above.

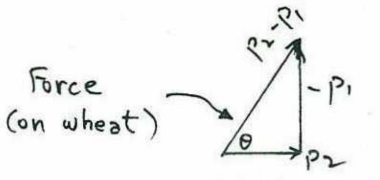
$$\tan\theta = 58.6 / 12.5 \text{ so } \theta = 78.0^{\circ}$$ ← 1 mark

This force is directed to the left and below the horizontal as shown in the diagram.

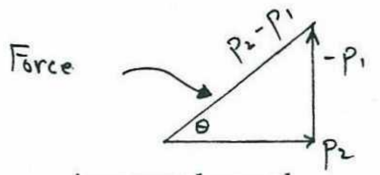
3 (~~2~~ marks)

d) If the speed of the conveyor belt is increased, there would be a greater change in the horizontal momentum. This means that the angle θ would decrease and the magnitude of the force would increase as shown in the diagram :

Must give both points for 1 mark.



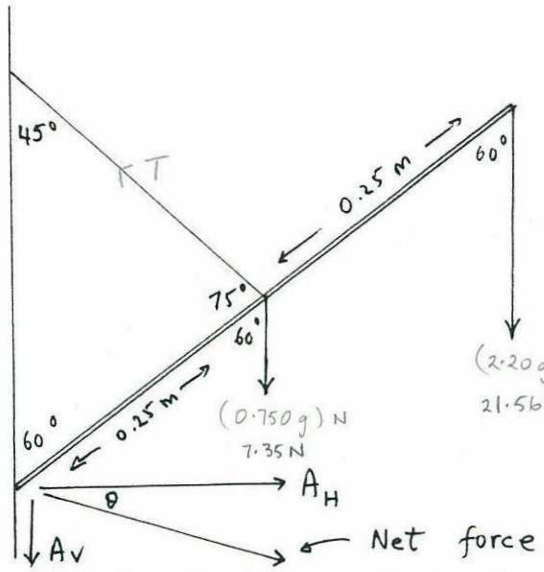
original speed



increased speed

1 (~~2~~ marks)

B8.



a) Write T for the tension in the rope. Calculate the moments about point A :

clockwise moments = anticlockwise moments

$$(0.750 \text{ g} \times 0.25) \sin 60 + (2.2 \text{ g} \times 0.5) \sin 60 = (T \times 0.25) \sin 75$$

Hence $T = 45.25$ N (2 marks)

b) The net vertical force exerted on the boom must equal zero. Thus if A_V is the vertical force exerted by the wall on the boom,

$$A_V + 0.750 \text{ g} + 2.2 \text{ g} - T \cos 45 = 0$$

$$\therefore \quad A_V = 3.09 \text{ N}$$

Similarly the sum of the horizontal forces must be zero, from which we see that the horizontal force exerted by the wall on the boom is

$$A_H = T \sin 45 = 32.0 \text{ N}$$

The net force is thus $\sqrt{(3.09^2 + 32.0^2)} = 32.1$ N

The angle between this force and the vertical is

$$\theta = \tan^{-1}(32/3.09) = 84.5^{\circ}$$

3 (~~2~~ marks)

c) If the angle BAC were increased, the tension will increase. This can be seen by rearranging the equation in part a). Thus both the horizontal and vertical forces at A would increase, and the total force increases also. The vertical force increases at a faster rate, so the angle θ will ~~decrease~~. increases.

Must give both magnitude + direction.

1 (~~2~~ marks)