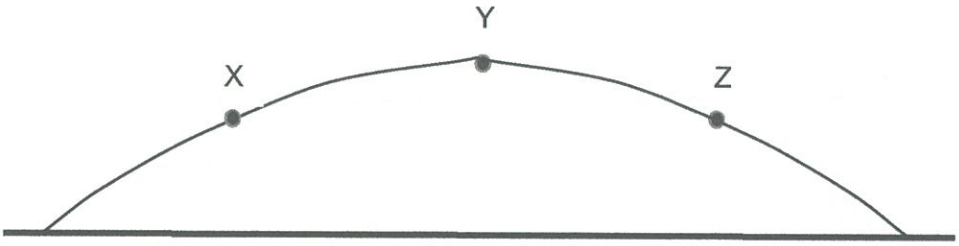
Section One: Short response 30% (60 Marks)

This section has **12** questions. Answer **all** questions.

Suggested working time: 55 minutes.

Question 1 (4 marks)

The diagram below shows the trajectory of a projectile as it travels from left to right (i.e. from X to Y to Z).



	At 'X'	At 'Y'	At 'Z'
A	↙	←	↖
B	↓	↓	↓
C	↗	→	↘
D	↓	↑	↓
E	↓	0	↑
F	↑	0	↓

(a) Which set of vectors (A – F) best illustrates the acceleration experienced by the ball in flight (ignore air resistance)? (1 mark)

B

(b) Which set of vectors (A – F) best illustrates the instantaneous velocity of the ball in flight (ignore air resistance)? (1 mark)

C

(c) Which set of vectors best illustrates the vertical component of the ball's velocity in flight (ignore air resistance)? (1 mark)

F

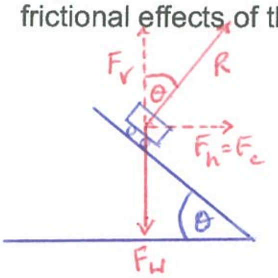
(d) If air resistance is taken into account, which set of vectors best illustrates the force due to this air resistance experienced by the ball in flight? (1 mark)

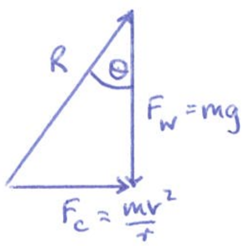
A

[1 mark each]

Question 2 **(5 marks)**

The banking of roads can help cars navigate high speed bends safely. Derive an equation to calculate the angle to the horizontal that a road should be inclined for a 1.50 x 10^3 kg car to negotiate a horizontal circular path with a radius of 2.50 x 10^2 m at 1.10 x 10^2 kmh^{-1}. (Ignore the frictional effects of the road on the car.)





$$\tan\theta = \frac{F_c}{F_W}$$
$$= \frac{\cancel{m}v^2}{r} \times \frac{1}{\cancel{m}g} \quad (1)$$
$$\Rightarrow \tan\theta = \frac{v^2}{gr} \quad (1)$$
$$= \frac{(30.6)^2}{(9.80)(2.50\times10^2)} \quad (1)$$

Conversion (1)

$$= 0.3822$$
$$\Rightarrow \underline{\theta = 20.9^\circ} \quad (1)$$

Question 3 **(5 marks)**

The table below shows some data for two planets orbiting a distant star in another galaxy. Kepler's Third Law relates the radius and period of orbit for planets orbiting a star.

Planets	Mass (kg)	Orbital radius (m)	Radius of planet (m)	Length of one day (s)	Orbital period (s)
Alpha	1.15 x 10^{25}	4.50 x 10^{11}	7.90 x 10^6	9.60 x 10^4	8.50 x 10^7
Beta	1.60 x 10^{24}	9.00 x 10^{11}	3.80 x 10^6	4.80 x 10^4	-

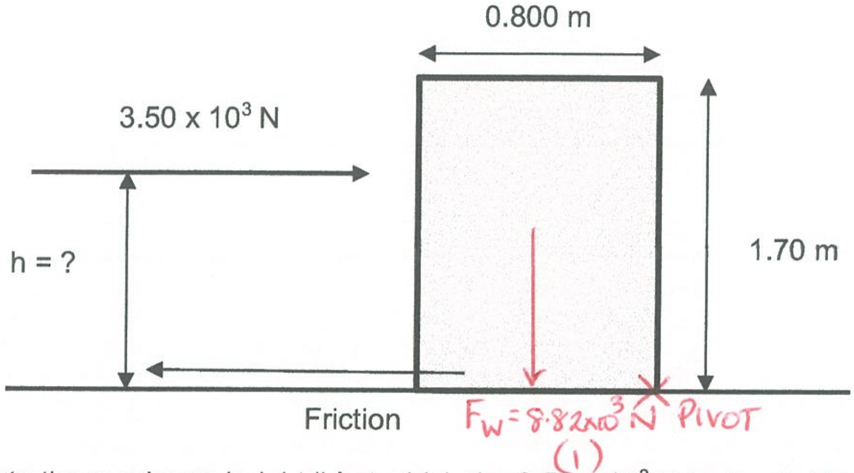
Use this information and appropriate data from the table to calculate the value for the orbital period of Beta.

$$r^3 = \frac{GM_{star}T^2}{4\pi^2}$$
$$\Rightarrow \frac{r^3}{T^2} = \frac{GM_{star}}{4\pi^2} = \text{constant} \quad (1)$$
$$\therefore \frac{r^3_{Alpha}}{T^2_{Alpha}} = \frac{r^3_{Beta}}{T^2_{Beta}} \quad (1)$$
$$\Rightarrow \frac{(4.50\times10^{11})^3}{(8.50\times10^7)^2} = \frac{(9.00\times10^{11})}{T^2_{Beta}} \quad (1)$$
$$\Rightarrow \underline{T_{Beta} = 2.40\times10^8\ s} \quad (1)$$

[Chooses r and T data - 1 mark]

Question 4 **(5 marks)**

A uniform concrete block is 1.70 m tall, 0.800 m wide and 0.900 m deep; it has a mass of 9.00×10^2 kg. A minimum horizontal force of 3.50×10^3 N is required to start sliding the block across the ground.



(a) Calculate the maximum height 'h' at which the 3.50×10^3 N horizontal force could be applied without tipping the block over. (3 marks)

$$\Sigma CM = \Sigma ACM$$

$$\Rightarrow (3.50 \times 10^3)\, h = (8.82 \times 10^3)(0.400) \quad (1)$$

$$\Rightarrow \underline{h = 1.01 \text{ m}} \quad (1)$$

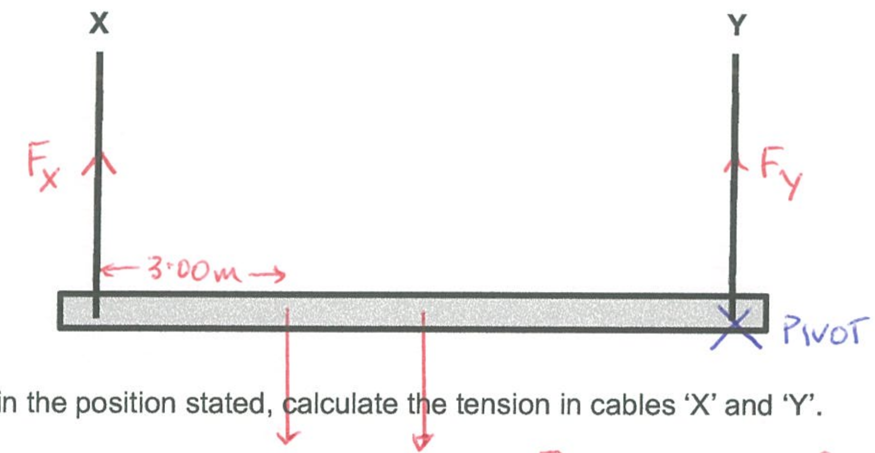
(b) If the ground became more slippery due to rain falling on it, does the block become harder or easier to tip over. Explain briefly. (2 marks)

- Harder to tip over. (1)
- Less friction means the applied force will be less – otherwise the block will slide. (1)

[May also mention that h must increase – could be greater than 1.70m and the block won't tip.]

Question 5 **(5 marks)**

A uniform, 35.0 kg horizontal platform is supported by two vertical steel cables 'X' and 'Y' situated 10.0 m apart as shown. A person with a mass of 85.0 kg stands 3.00 m from 'X'.



With the person in the position stated, calculate the tension in cables 'X' and 'Y'.

833N 343N [Calculation of weights - 1 mark]

Take Y as pivot.

$\Sigma CM = \Sigma ACM$

$\Rightarrow (833)(3{\cdot}00) + (343)(5{\cdot}00) = F_Y(10{\cdot}0)$ (1)

$\Rightarrow \underline{F_Y = 421\ N}$ (1)

$\Sigma F_V = 0$

$\Rightarrow F_X + 421 = 833 + 343$ (1)

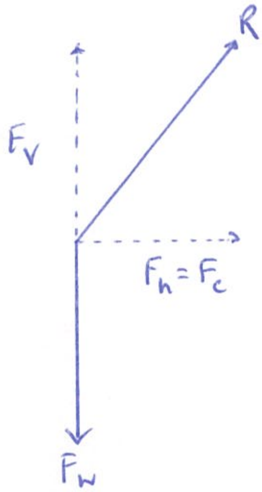
$\Rightarrow \underline{F_X = 755\ N}$ (1)

Question 6 **(4 marks)**

The diagram shows a cyclist rounding a circular bend on his bicycle.

(a) Show with an arrow the nett force on him as he rounds the bend. (1 mark)

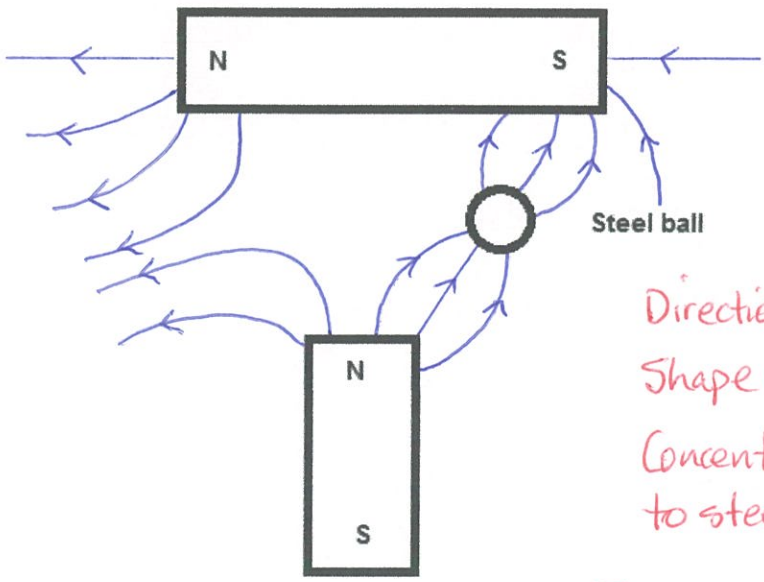
(b) Explain why the rider must lean his bicycle as he takes the corner. (3 marks)



- If the rider doesn't lean, the tyres won't generate enough sideways friction to make it around the corner. (1)
- By leaning, the reaction force has a horizontal component. (1)
- This provides the centripetal force required to safely make it around the corner. (1)

Question 7 **(5 marks)**

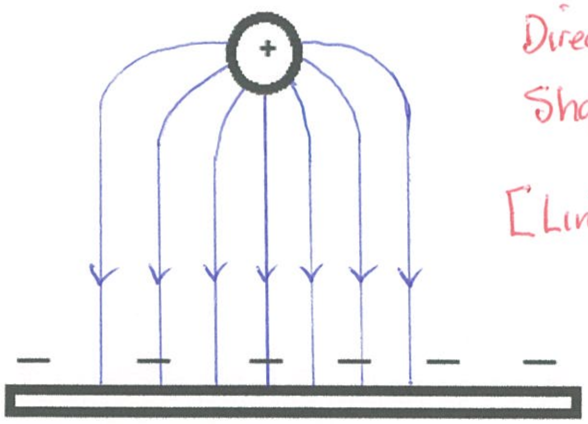
(a) On the following diagram, draw the magnetic fields between the magnets and the steel ball. (3 marks)



Direction of field (1)
Shape of fields (1)
Concentration of field to steel ball (1)

[Lines touch - 1 mark off]

(b) Draw the electric field between the negative plate and the charged sphere in the following diagram. (2 marks)

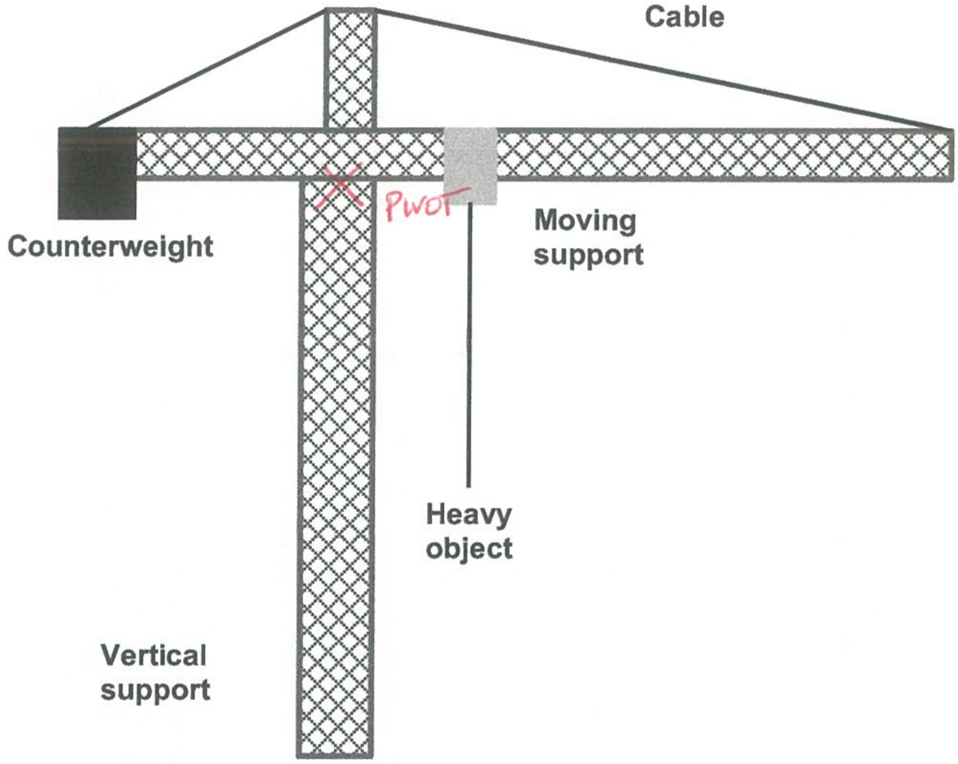


Direction of field (1)
Shape of field (1)

[Lines touch - 1 mark off].

Question 8 **(4 marks)**

The diagram below shows a crane supporting a "heavy object" as shown. The "moving support" can be moved towards the "vertical support" or away from it.



(a) Explain the role of the "counterweight" and "cable" in this structure. (2 marks)

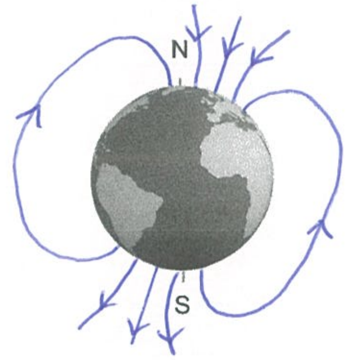
- The heavy object and the arm of the crane provide clockwise moments around the pivot on the vertical support. (1)
- The counterweight and the tension in the cable provide anticlockwise moments about the pivot and keep the crane in mechanical equilibrium. (1)

(b) Explain how the tension in the cable changes if the 'heavy object" is moved to the right by the "moving support". (2 marks)

- Moving the heavy object to the right increases the clockwise moments. (1)
- The tension in the cable must increase to increase the anticlockwise moments to maintain equilibrium. (1)

Question 9 **(7 marks)**

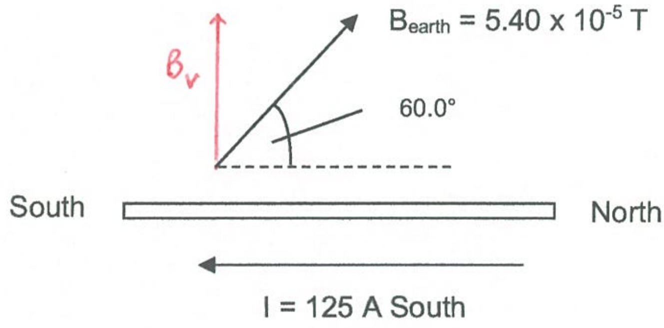
(a) On the diagram, show the magnetic field of the Earth. (3 marks)



Direction of field (1)
Shape of field (1)
Field at angle to N-S axis (1)

(b) An alternating current of 125 A flows a 50.0 m span of transmission cable that is orientated in a north-south direction. The transmission cable is located at a point in Western Australia where the Earth's magnetic field intensity is 5.40 x 10^{-5} T at 60.0 ° angle of dip. Assume the cable is horizontal along its length.

At the instant that the current is flowing towards South, what would be the force acting on the length of the wire? (4 marks)



Looking west

Correct component (1)

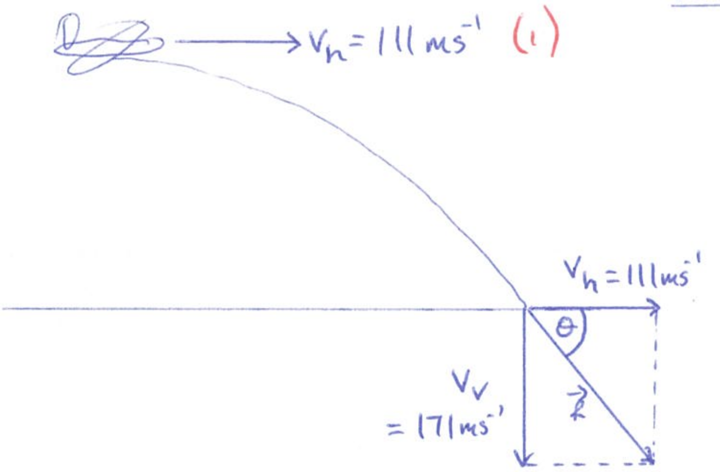
$F = I l B_v$

$= (125)(50.0)(5.40 \times 10^{-5} \cos 30.0°)$ (1)

$= \underline{0.292 \text{ N West}}$
(1) Direction (1)

Question 10 **(5 marks)**

An aeroplane is being flown with its maximum horizontal speed of 4.00×10^2 kmh^{-1} at an altitude of 1.50×10^3 m. A piece of the plane becomes dislodged and drops off it whilst it is in motion.
If air resistance can be ignored, calculate the velocity of this piece of the plane when it lands on the ground (in ms^{-1}).



VERTICALLY $\downarrow$ +VE

$v = ?$
$u = 0\ ms^{-1}$
$a = 9.80\ ms^{-2}$
$t = ?$
$s = 1.50 \times 10^3\ m$

$v^2 = u^2 + 2as$
$= 0 + 2(9.80)(1.50 \times 10^3)$ (1)
$\Rightarrow v = 171\ ms^{-1}$ down (1)

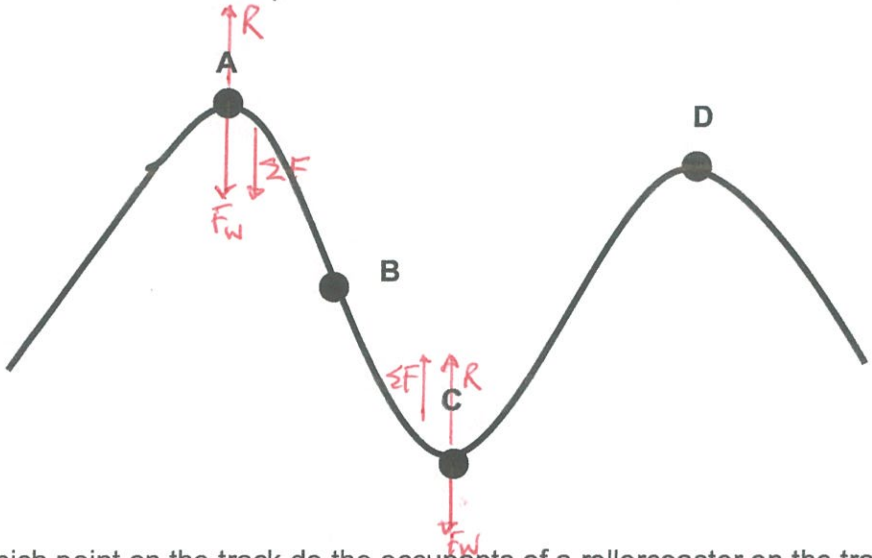
$\vec{R} = \sqrt{(111)^2 + (171)^2}$
$= 204\ ms^{-1}$ (1)

$\tan\theta = \frac{171}{111}$
$\Rightarrow \theta = 57.0^\circ$ (1)

$\therefore$ v_{impact} = 204 ms^{-1} at 57.0° to the horizontal

Question 11 **(6 marks)**

The diagram below shows four positions on a rollercoaster track.



(a) At which point on the track do the occupants of a rollercoaster on the track experience MAXIMUM normal force? Justify your answer. (3 marks)

• Point C. (1)

$$\Sigma F = F_c = R - F_W$$

$$\Rightarrow \quad R = F_c + F_W \quad (1)$$

∴ Apparent weight R is greater than the real weight F_W by an amount F_c (due to the circular motion). (1)

(b) The occupants of the rollercoaster feel 'weightless' at A. Derive an expression relating the instantaneous speed *v* of the rollercoaster and the radius of the track *r* at A to cause this sensation. (3 marks)

$$\Sigma F = F_c = F_W - R$$

If $R = 0 \Rightarrow \quad F_c = F_W \quad (1)$

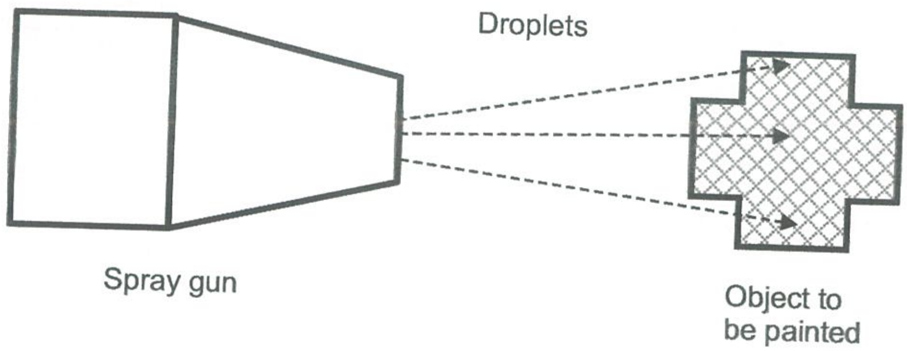
$$\Rightarrow \frac{mv^2}{r} = mg \quad (1)$$

$$\Rightarrow \quad v = \sqrt{gr} \quad (1)$$

Question 12

(5 marks)

In an electrostatic spray painting system, droplets of paint are ejected from a positively charged spray gun to the object to be painted, which is negatively charged.



The magnitude of the charge on each droplet is 2.00×10^{-10} C and, on average, they have a diameter of about 1.50×10^{2} μm.

(a) State whether electrons were added to or removed from the droplets of paint by the spray gun.
(1 mark)

• Removed. (1)

(b) Calculate the electrostatic force acting between adjacent droplets if their surfaces are virtually touching.
(4 marks)

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}$$

$$= \frac{1}{4\pi(8.85\times10^{-12})} \cdot \frac{(2.00\times10^{-10})^2}{(1.50\times10^{-4})^2} \quad (1)$$

Conversion (1)

$$= 1.60\times10^{-2}\ \text{N repulsion}$$

(1) (1)