

Practice Paper G

Paper 3: Statistics and Mechanics

1/a The pmcc measures the strength of the linear relationship between the CO₂ emissions and fuel consumption

b 60 mpg is outside the data range and so may be unreliable

c The explanatory variable is the one that affects the other, so it is the fuel consumption

d A hypothesis test is a statistical test used to determine whether a hypothesis assumed for a sample of data is true for an entire population

e $H_0: \rho = 0$ $H_1: \rho < 0$
this must be a 1-tailed test since says "less than zero"

$$\therefore r = -0.803, \quad n = 40$$

Using the statistical table for critical values, critical value is 0.3665

$$-0.3665 > -0.803$$

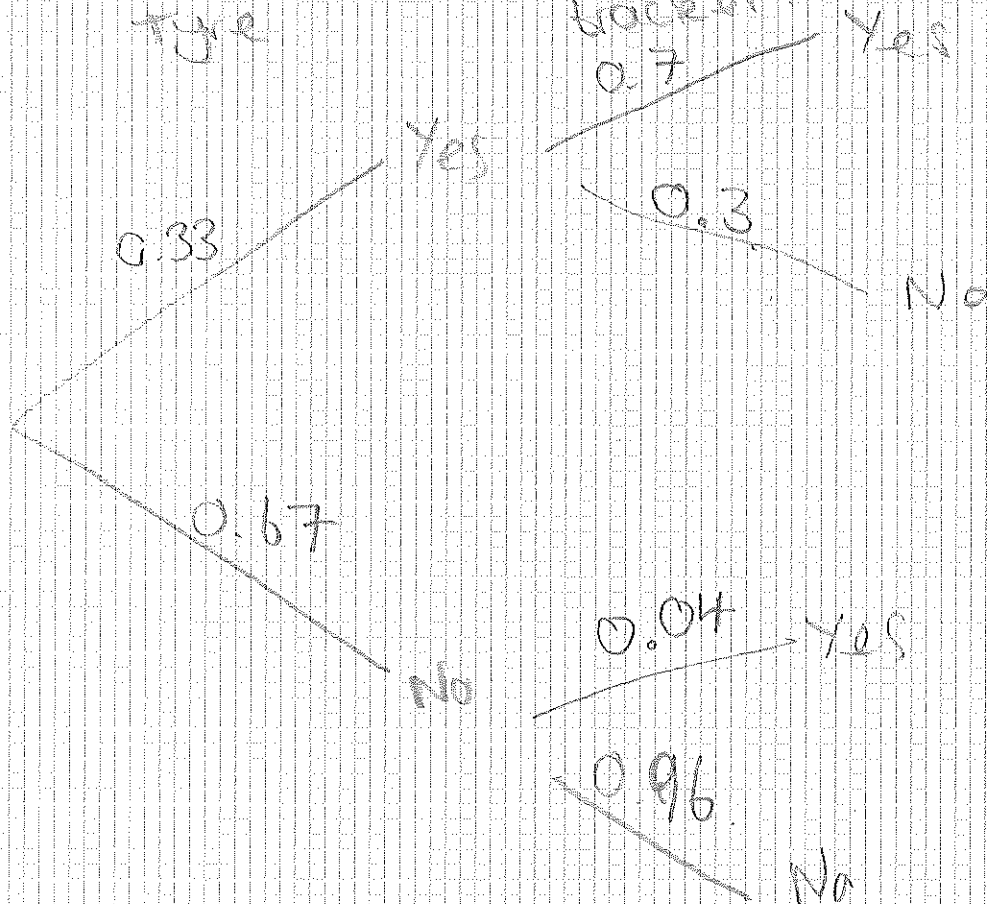
\therefore there is evidence that we can reject the null hypothesis and that the pmcc for

CO₂ emissions and fuel consumption is less than zero.

2/a $P(\text{new tyre}) = 0.33$

$P(\text{new tracking given new tyre}) = 0.7$

$P(\text{not new tyre but needing tracker}) = 0.04$



b $P(\text{tyre but not tracker}) = 0.33 \times 0.3 = 0.099$

$P(\text{tracker but not tyre}) = 0.67 \times 0.04 = 0.0268$

$0.099 + 0.0268 = 0.1258$

c $P(\text{at least 1 defect})$

$= 1 - P(\text{no defects})$

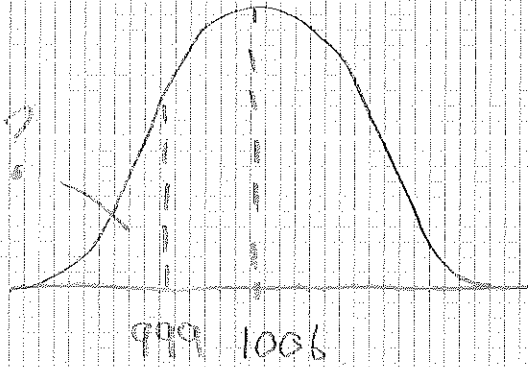
$= 0.67 \times 0.96 \times (1 - 0.35) = 0.418$

$1 - 0.418 = 0.582$

d The advice would be to get cars regularly serviced as there is a 50% chance something is defective.

3 a It is reasonable as the distribution has the bell shape of the normal distribution.

b Poor or bad weather; less than 1000



$$X \sim N(1006, 4.4^2)$$

$$P(X < 1000)$$

using classviz, normal CD,
lower = -10,000

$$\text{upper} = 1000$$

$$= \underline{0.0863}$$

c Hurricane could still happen as there could be 'extreme circumstances' in reality, despite the model.

d $X \sim N(1017, 3.26^2)$

$$P(X < 1000) = P(\leq 9.20459 \times 10^{-8})$$

it is very very unlikely that is poor weather the mean is higher suggesting better weather also, and the standard deviation is smaller showing there is less variation in the weather.

Therefore, the information supports his claim.

4 a The pmcc measured the strength of the linear correlation between the 2 variables.

b The pmcc of -0.477 shows there is some negative correlation between mean windspeed and mean pressure.

c This means that as the pressure increases the daily mean windspeed in Hurn decreases.

d $H_0: \rho = 0$ $H_1: \rho < 0$

$$\text{pmcc} = -0.477$$

$$p\text{-value} < 0.001$$

as this is less than 0.1%,

it is less than the 5% significance level, there is evidence to reject H_0 and there is evidence that there is a negative correlation between mean pressure and mean wind speed.

e If we use the regression model,

$$\text{km} = 180 - 0.1694 \times \text{hPa}$$

f the gradient tells us that every time the mean pressure increases by 1, the speed decreases by 0.1694 km.

g This is near the bottom of the range so may not be very accurate.

5 $P(E) = 0.25$ $P(F) = 0.4$
 $P(E \cap F) = 0.12$

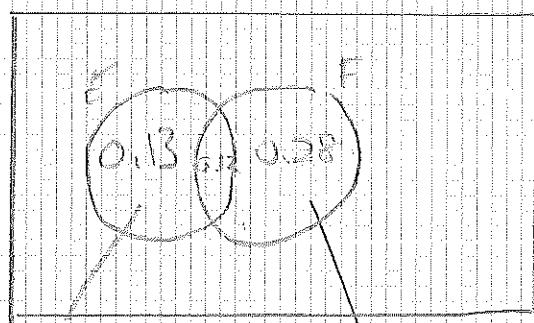
a $P(E' | F')$

using the rule for conditional probability;

$$P(B|A) = \frac{P(A \cap B)}{P(B)}$$

or

Venn diagram;



$$0.25 - 0.12 = 0.13$$

$$0.4 - 0.12 = 0.28$$

$$P(F') = 0.6$$

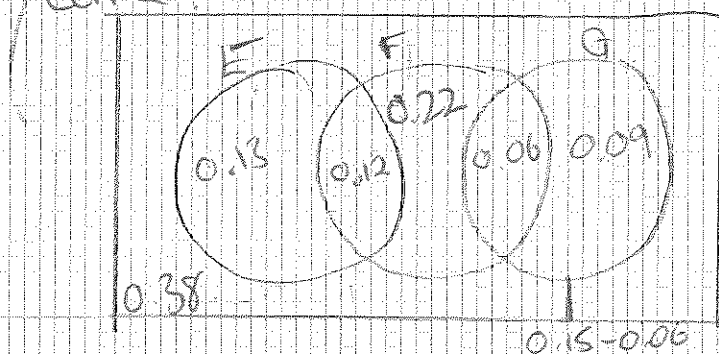
$$P(E' | F') = \frac{0.47}{0.6} = 0.783$$

b Independent if $P(E \cap F) = P(E) \times P(F)$
 $P(E) \times P(F) = 0.25 \times 0.4 = 0.1$

$$P(E \cap F) = 0.12 \quad 0.1 \neq 0.12$$

\therefore not independent

c E and G don't overlap since can't happen at same time.



F and G independent,
 so $P(F \cap G) = 0.15 \times 0.4 = 0.06$

$$\frac{d}{d} P((FUG) \dots)$$

$$= 0.38 + 0.13$$

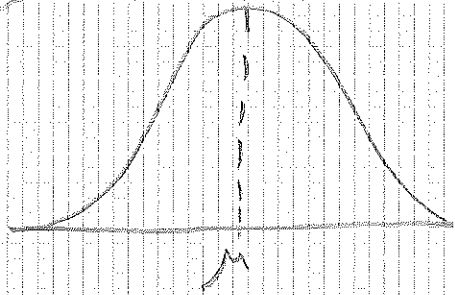
$$= 0.51$$

6 54% female 46% male
 $n = 200$

Binomial

$$X \sim B(200, 0.54)$$

Binomial



$$X \sim B(n, p)$$

$$\mu = np$$

$$\sigma^2 = n \times p \times (1-p)$$

$$\mu = 200 \times 0.54$$

$$= 108$$

$$\sigma^2 = 200 \times 0.54 \times 0.46$$

$$= 49.68$$

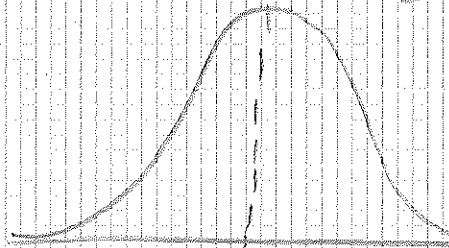
using calculator

$$P(X > 101) = P(X > 100.5)$$

↓ for normal - since continuous

using calc = 0.856

Normal

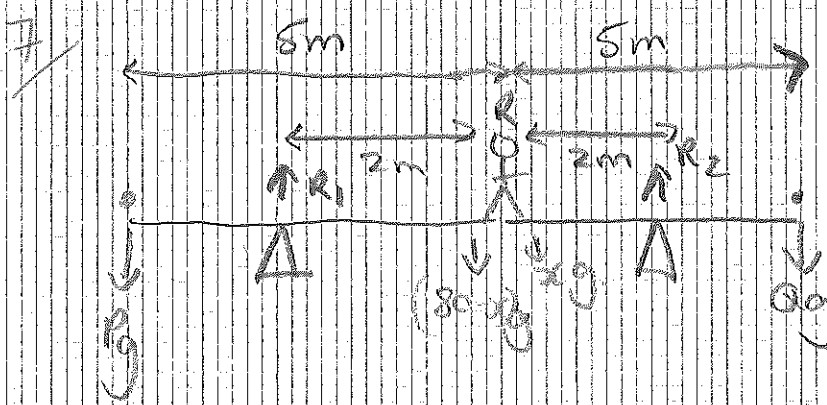


$$\mu = 0 \quad \text{s.d} = 1$$

$$Z \sim N(\mu, \sigma^2)$$

$$\sigma^2 = npq$$

$$= np(1-p)$$



2 see-saws not joined just touching!

Moments around R_1

<u>clockwise</u>	<u>anti</u>
$(80-x)g$	$P_g \times 3$
$2(80-x)g - P_g \times 3$	
① $160g - 200g = -3P_g$	

Sub ② into ①

Moments around R_2

<u>clockwise</u>	<u>anti</u>
$Qg \times 3$	$x \times 2$
$200g = 3Qg$	
② $200g = 3Qg$	

$$160g = 3Qg = 3P_g$$

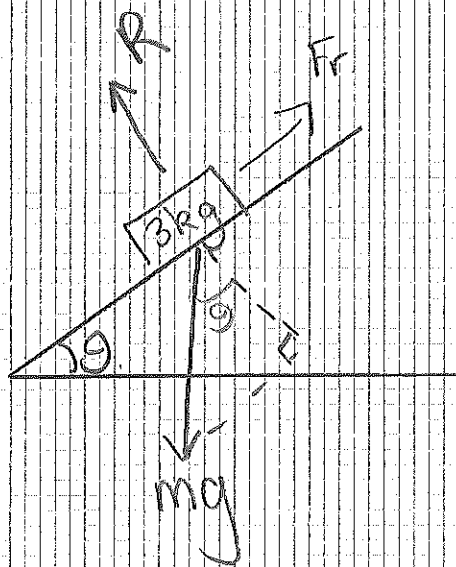
$$160g = 3Qg + 3P_g$$

$$160 = 3Q + 3P$$

$$Q + P = 53$$

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8/a



R is the normal reaction from the slope.

F_r is the friction

mg is the weight of the object

where $m = 3$

b Resolve \perp to slope

$$\textcircled{1} \quad mg \cos \theta = R$$

Resolve \parallel to slope

$$mg \sin \alpha = F_r$$

Limiting equilibrium $\therefore F_r = \mu R$

$$\textcircled{2} \quad mg \sin \alpha = \mu R$$

sub $\textcircled{1}$ into $\textcircled{2}$

$$mg \sin \alpha = \mu (mg \cos \alpha)$$

$$\frac{mg \sin \alpha}{mg \cos \alpha} = \mu$$

$$\tan \alpha = \mu$$

c If $\mu = 0.3$ and $\theta = 30^\circ$

$$mg \cos \theta = R$$

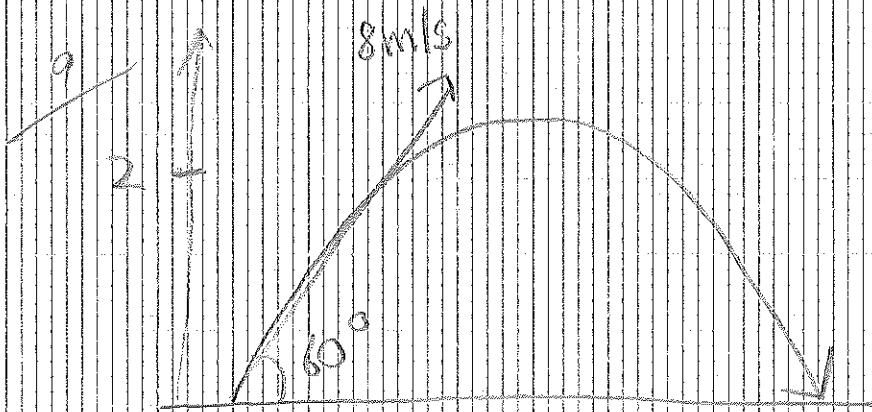
$$3g \times \cos 30 = R$$

$$R = 25.46$$

$$\mu R = 0.3 \times 25.46 = 7.64$$

$$mg \sin \alpha = mg \sin 30 = 14.7$$

a) no object remains in equilibrium as the normal reaction is $mg \cos \theta$
 so if $\theta = 90$, $mg \cos \theta = 0$
 no normal reaction



resolve \uparrow

$$s = 2$$

$$u = 8 \sin 60$$

$$v = ?$$

$$a = -9.8$$

$$t = ?$$

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

$$2 = 8 \sin 60 t - 4.9t^2$$

$$4.9t^2 - 8 \sin 60 t + 2 = 0$$

$$t = 0.4043 \text{ and}$$

$$1.0097 \text{ s}$$

$$1.0097 - 0.4043$$

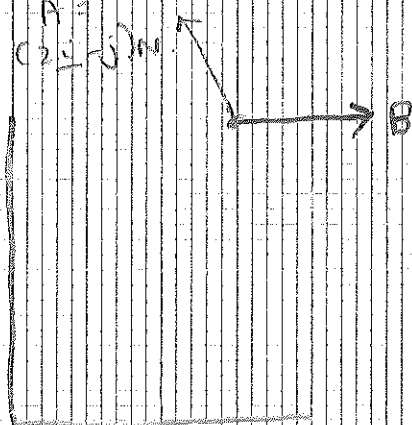
$$= 0.6054 \text{ s}$$

so

$$A = (2i - j) \text{ N}$$

$$B = i \text{ N}$$

$$A = (2i - j) \text{ N}$$



Resultant force

$$= A + B =$$

$$2i - j + i = (3i - j) \text{ N}$$

$$F = ma$$

$$\begin{pmatrix} 3 \\ -1 \end{pmatrix} = 0.5a$$

$$a = \begin{pmatrix} 6 \\ -2 \end{pmatrix}$$

$$a = 6\mathbf{i} - 2\mathbf{j}$$

$$s = ?$$

$$u = 0$$

$$v = ?$$

$$a = 6\mathbf{i} - 2\mathbf{j}$$

$$t = t$$

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

$$s = 0 + \frac{1}{2} \times (6\mathbf{i} - 2\mathbf{j})t^2$$

$$s = (3\mathbf{i} - \mathbf{j})t^2$$

$$s = (3\mathbf{i} - \mathbf{j})t^2 + (3\mathbf{i} + 4\mathbf{j})$$

x co-ordinate

$$= 3t^2 + 3 = 3t^2 + 3$$

y co-ordinate

$$= -t^2 + 4 = -t^2 + 4$$

b the particle never returns to its starting point since the x co-ordinate will be always be greater than 3 since always $3t^2 > 0$

c An object with 2 forces acting on it e.g. A wind and B a current

$$r = \begin{pmatrix} \cos 2t \\ \sin 2t \end{pmatrix}$$

differentiate position for velocity

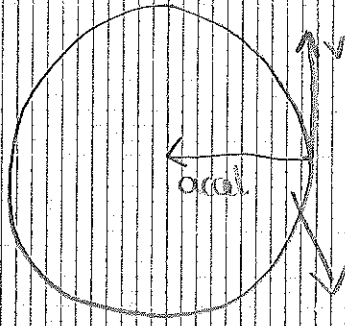
$$v = \begin{pmatrix} -2\sin 2t \\ 2\cos 2t \end{pmatrix}$$

differentiate again for acceleration

$$a = \begin{pmatrix} -4\cos 2t \\ -4\sin 2t \end{pmatrix}$$

$$\frac{b}{r} = \begin{pmatrix} \cos 2t \\ \sin 2t \end{pmatrix}$$

$$a = -4 \begin{pmatrix} \cos 2t \\ \sin 2t \end{pmatrix} = -4r$$



velocity

planet

it be orbiting will be
a force that will
pull it towards the
centre