AQA AS-Level Further Mathematics Warmup - Paper 2MS 2025

A CRV X, has probability density function given by
$$f(x) = \begin{cases} 3x^a; & 0 \le x \le 1 \\ 0; & \text{otherwise} \end{cases}$$
Find the constant a and the median value M, of X.

A particle of mass $2m$ is tied to a fixed point O on a smooth horizontal table by a light elastic string of natural length 0.5 m and modulus of elasticity $\lambda = m$. The particle moves with a constant angular speed of 5 rpm about O. Calculate the extension in the string.

The number of cars passing a point on a rural road between 7am and 8am is given by the random variable X. Why is a Poisson a suitable model for this situation? Given that on average 6 cars pass the point every 15 minutes find the probability that the the number of cars passing between 7am and 8am is between 25 and 30 inclusive.

In the topic of collisions how do you define the coefficient of restitution?

A particle P of mass 1kg is moving at a speed of 5ms-1 collides with a particle Q of mass 2kg which is at rest. Given that after the collision P moves with speed 2ms-1, find the speed of Q after the collision.

A Poisson distribution is believed to have a parameter of 16.
A sample is taken to determine whether the parameter is different to this. State the null and alternative hypotheses for this test.

A particle of mass 1.2 kg is acted on by a time dependent force of $F = 2t + 3\mathrm{e}^{-2t}$. Find the impulse exerted by this force if the force is applied for 2 seconds.

The lunch choices of two year groups at school are tested for association.
A total of 120students in both year 12 and 13 are asked.
In Year 12 38 chose burger, 62 pizza and 20 salad.
In Year 13, 48 chose burger, 43 pizza and 29 salad.
Perform a χ^2 test at $5\,\%$ for association.

A Geiger counter detects radioactive decays at a mean rate of 20 per minute. Find the probability that in a given, randomly chosen minute, there are
i) 23 decays
ii) More than 25 decays

The excess pressure, P, inside a soap bubble is given by the formula
$$P = 4r^{\alpha}s^{\beta}$$
where r is the radius, s is the surface tension and α and β are constants. Given that surface tension is defined to be force per unit length determine the values of α and β in the model for P.

Tom pulls a crate with a rope parallel to the horizontal floor with a constant tension of 25 N. The crate passes points A and B which are 5m apart in a time of 2 seconds with speeds 2 ms-1 and 4 ms-1 respectively.
Find the average power.

What are Type I and Type II errors?

A CRV X, has probability density function given by
$$f(x) = \begin{cases} kx; & 0 \le x \le 5 \\ 0; & \text{otherwise} \end{cases}$$
Find the constant k, $P(X \ge 3)$ and $\mathrm{E}(X)$ and $\mathrm{Var}(X)$

Find the work done when a light elastic string of natural length 1.4 m and modulus of elasticity 60 N is stretched from a length of 1.5 m to 1.6m.

Let X be a discrete random variable with $\mathrm{E}(X) = 5$ and $\mathrm{Var}(X) = \dfrac{3}{2}$.
Find $\mathrm{E}(3X + 4)$ and $\mathrm{Var}(3X + 4)$.
Find also $\mathrm{Var}(2X)$ and $\mathrm{Var}(X + X)$

Derive the mean for a discrete uniform distribution $X \sim U(n)$. State the formula for the $\mathrm{Var}(X)$

A string with natural length 6m and modulus of elasticity 15 N is extended by 1m.
Find,
a) The stiffness of the string
b) The tension in the string and the EPE stored in it.

A body moving on a horizontal circular path of radius r with a constant angular velocity has:

speed -
acceleration -
centripetal force -

A particle of mass 3 kg which is initially at rest falls 10m freely under gravity to hit the ground. Using $g = 10$ ms-2 find the final speed v if
a) Air resistance is neglected.
b) Air resistance is modelled way a constant force of 3 N.
What is a limitation of this

The expected value of a function $g(X)$ of a discrete random variable X is given by:

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$\int_0^1 3x^a \, dx = 1 \quad \Rightarrow \quad a = 2$ $\int_0^M 3x^2 \, dx = \frac{1}{2}$ $\Rightarrow \quad M^3 = \frac{1}{2}$ $\Rightarrow \quad M \approx 0.7937$	5 rpm = $\frac{10\pi}{60} = \frac{\pi}{6}$ rads-1. Apply $F = ma$ towards the centre of the circle to get, where x is the extension. $T = 2mr\omega^2$ $= 2m(0.5+x)\left(\frac{\pi}{6}\right)^2$ But by Hooke's law $T = \frac{\lambda x}{l} = \frac{mx}{0.5} = 2mx.$ Hence $x = 0.19$m	On a quiet road cars are likely to arrive randomly and singly in time. Average number of cars passing in an hour is 24. Let $X \sim \text{Po}(24)$. Then $P(25 \leq X \leq 30) = 0.3502.$	$e = \frac{\text{Speed of separation}}{\text{Speed of approach}}$ $= \frac{v_2 - v_1}{u_1 - u_2}$ where the velocities before impact are u_1 and u_2 and the velocities after the collision v_1 and v_2	Using $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$,we have $1 \times 5 + 2 \times 0 = 1 \times 2 + 2 \times v_2$ Hence, $2v_2 = 3$ and so $v_2 = 1.5$ ms-1
$H_0 : \lambda = 16$ $H_1 : \lambda \neq 16$	$I = \int_0^2 F \, dt$ $= \int_0^2 2t + 3e^{-2t} \, dt$ $= \frac{11}{2} - \frac{3}{2e^4}$	H_0 : no association H_1 : there is an association χ^2 test statistic $= 6.25394716$ 2 degrees of freedom. Critical value is 5.991 Hence, there is sufficient evidence to reject H_0 and conclude that there is a possible association between year group	Let $X \sim \text{Po}(20)$. Then $P(X = x) = e^{-20}\frac{20^x}{x!}.$ $P(X = 23) = 0.0669$ $\text{P}(X > 25) = 1 - \text{P}(X \leq 25)$ $= 0.1122$	Using dimensional analysis, $ML^{-1}T^{-2} = L^\alpha(MT^{-2})^\beta$ Comparing powers, $1 = \beta$ $-1 = \alpha$ $-2 = -2\beta$ Hence, $P - 4r^{-1}s$
Average power = work done divided by the time taken. Work done = force × distance. So average power = $\frac{25 \times 5}{2} = \frac{125}{2}$ W	A Type I error is when a null hypothesis which is true is rejected (sometimes called a false positive). A type II error is when a null hypothesis which is false is not rejected (sometimes called a false negative)	$\int_0^5 kx \, dx = 1 \Rightarrow k = \frac{2}{25}$ $P(X \geq 3) = \int_3^5 \frac{2}{25}x \, dx = \frac{16}{25}$ $\text{E}(X) = \int_0^5 \frac{2}{25}x^2 \, dx = \frac{10}{3}$ $\text{E}(X^2) = \int_0^5 \frac{2}{25}x^3 \, dx = \frac{25}{2}$ $\text{Var}(X) = \text{E}(X^2) - (\text{E}(X))^2 = \frac{25}{18}$	Work done $= \frac{\lambda}{2l}(x_2^2 - x_1^2)$ So work done = $= \frac{60}{2.8}(0.2^2 - 0.1^2) = \frac{9}{14}J$	$\text{E}(3X+4) = 3\text{E}(X) + 4 = 19$ $\text{Var}(X) = 3^2\text{Var}(X) = 9 \times \frac{3}{2} = \frac{27}{2}$ $\text{Var}(2X) = 2^2\text{Var}(X) = 4 \times \frac{3}{2} = 6$ $\text{Var}(X+X) = \frac{3}{2} + \frac{3}{2} = 3$
$E[x] = \sum_{r=1}^{n} r \times \frac{1}{n}$ $= \frac{1}{n}\frac{r(n+1)}{2}$ $= \frac{n+1}{2}$ $\text{Var}(x) = \frac{n^2-1}{12}$	**a)** Stiffness = $\frac{\lambda}{l} = \frac{15}{6}$ **b)** Tension = $\frac{\lambda x}{l} = \frac{15 \times 1}{6} = \frac{15}{6}$ N $\text{EPE} = \frac{\lambda x^2}{2l} = \frac{5}{4}$ J	**Speed**: $v = r\omega$, constant along the tangent. **Acceleration**: $a = r\omega^2 = \frac{v^2}{r}$ towards the centre. **Centripetal Force:** $F = mr\omega^2 = m\frac{v^2}{r}$	**a)** GPE lost = KE gained. So, $300 = \frac{1}{2} \times 3 \times v^2 \Rightarrow v^2 = \sqrt{200}$ so $v = 10\sqrt{2}$ ms-1 **b)** GPE Lost = KE Gained + Work done against resistance. So, $3 \times 10 \times 10 = \frac{1}{2} \times 3 \times v^2 + 3 \times 10$ So $v^2 = 180$ and $v = 6\sqrt{5}$ ms-1 Air resistance is likely proportional to the speed of the body.	$E\left[g(X)\right] = \sum_{\forall x} g(x)P(X = x)$