

AL/2016/10/E-I

සියලු ම හිමිකම් ඇවිරිණි / முழுப் பதிப்புரிமையுடையது / All Rights Reserved

ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව
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 இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம்

අධ්‍යයන පොදු කතික පත්‍ර (උසස් පෙළ) විභාග, 2016 අගෝස්තු
 கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2016 ஆகஸ்ட்
 General Certificate of Education (Adv. Level) Examination, August 2016

සංයුක්ත ගණිතය I இணைந்த கணிதம் I Combined Mathematics I	10 E I	පැය තුනයි மூன்று மணித்தியாலம் Three hours
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Index Number

Instructions:

- * This question paper consists of two parts;
Part A (Questions 1 - 10) and **Part B** (Questions 11 - 17).
- * **Part A:**
 Answer all questions. Write your answers to each question in the space provided. You may use additional sheets if more space is needed.
- * **Part B:**
 Answer five questions only. Write your answers on the sheets provided.
- * At the end of the time allotted, tie the answer scripts of the two parts together so that **Part A** is on top of **Part B** and hand them over to the supervisor.
- * You are permitted to remove **only Part B** of the question paper from the Examination Hall.

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(10) Combined Mathematics I		
Part	Question No.	Marks
A	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
B	11	
	12	
	13	
	14	
	15	
	16	
	17	
	Total	
	Percentage	

Paper I	
Paper II	
Total	
Final Marks	

Final Marks

In Numbers	
In Words	

Code Numbers

Marking Examiner	
Checked by:	1
	2
Supervised by:	

[see page two

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සියලු ම හිමිකම් ඇවිරිණි/முழுப் பதிப்புரிமையுடையது/All Rights Reserved]

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සංයුක්ත ගණිතය I
 இணைந்த கணிதம் I
 Combined Mathematics I

10 E I

PART B

* Answer five questions only.

11. (a) Let $a, b, c \in \mathbb{R}$ such that $a \neq 0$ and $a + b + c \neq 0$, and let $f(x) = ax^2 + bx + c$.

Show that 1 is not a root of the equation $f(x) = 0$.

Let α and β be the roots of $f(x) = 0$.

Show that $(\alpha - 1)(\beta - 1) = \frac{1}{a}(a + b + c)$ and that the quadratic equation with $\frac{1}{\alpha - 1}$ and $\frac{1}{\beta - 1}$ as the roots is given by $g(x) = 0$, where $g(x) = (a + b + c)x^2 + (2a + b)x + a$.

Now, let $a > 0$ and $a + b + c > 0$.

Show that the minimum value m_1 of $f(x)$ is given by $m_1 = -\frac{\Delta}{4a}$, where $\Delta = b^2 - 4ac$.

Let m_2 be the minimum value of $g(x)$. Deduce that $(a + b + c)m_2 = am_1$.

Hence, show that $f(x) \geq 0$ for all $x \in \mathbb{R}$ if and only if $g(x) \geq 0$ for all $x \in \mathbb{R}$.

(b) Let $p(x) = x^3 + 2x^2 + 3x - 1$ and $q(x) = x^2 + 3x + 6$. Using the remainder theorem, find the remainder when $p(x)$ is divided by $(x - 1)$ and the remainder when $q(x)$ is divided by $(x - 2)$.

Verify that $p(x) = (x - 1)q(x) + 5$, and find the remainder when $p(x)$ is divided by $(x - 1)(x - 2)$.

12. (a) Let $n \in \mathbb{Z}^+$. State, in the usual notation, the binomial expansion for $(1 + x)^n$.

Show, in the usual notation, that $\frac{{}^nC_{r+1}}{{}^nC_r} = \frac{n-r}{r+1}$ for $r = 0, 1, 2, \dots, n-1$.

The coefficients of x^r, x^{r+1} and x^{r+2} taken in that order, in the binomial expansion of $(1 + x)^n$ are in the ratios 1 : 2 : 3. In this case, show that $n = 14$ and $r = 4$.

(b) Let $U_r = \frac{10r + 9}{(2r - 3)(2r - 1)(2r + 1)}$ and $f(r) = r(Ar + B)$ for $r \in \mathbb{Z}^+$, where A and B are real constants.

Find the values of constants A and B such that

$$U_r = \frac{f(r)}{(2r - 3)(2r - 1)} - \frac{f(r + 1)}{(2r - 1)(2r + 1)} \text{ for } r \in \mathbb{Z}^+.$$

Show that $\sum_{r=1}^n U_r = -3 - \frac{(n+1)(2n+3)}{(4n^2-1)}$ for $n \in \mathbb{Z}^+$.

Show further that the infinite series $\sum_{r=1}^{\infty} U_r$ is convergent and find its sum.

13.(a) Let $A = \begin{pmatrix} -4 & -6 \\ 3 & 5 \end{pmatrix}$, $X = \begin{pmatrix} -1 \\ 1 \end{pmatrix}$ and $Y = \begin{pmatrix} -2 \\ 1 \end{pmatrix}$.

Find real constants λ and μ such that $AX = \lambda X$ and $AY = \mu Y$.

Let $P = \begin{pmatrix} -1 & -2 \\ 1 & 1 \end{pmatrix}$. Find P^{-1} and AP , and show that $P^{-1}AP = D$, where $D = \begin{pmatrix} 2 & 0 \\ 0 & -1 \end{pmatrix}$.

(b) In an Argand diagram, the point A represents the complex number $2+i$. The point B is such that $OB = 2(OA)$ and $\widehat{AOB} = \frac{\pi}{4}$, where O is the origin and \widehat{AOB} is measured counter-clockwise from OA . Find the complex number represented by the point B .

Also, find the complex number represented by the point C such that $OACB$ is a parallelogram.

(c) Let $z \in \mathbb{C}$ and $w = \frac{2}{1+i} + \frac{5z}{2+i}$. It is given that $\text{Im } w = -1$ and $|w - 1 + i| = 5$. Show that $z = \pm(2+i)$.

14.(a) Let $f(x) = \frac{(x-3)^2}{x^2-1}$ for $x \neq \pm 1$.

Show that $f'(x)$, the derivative of $f(x)$, is given by $f'(x) = \frac{2(x-3)(3x-1)}{(x^2-1)^2}$.

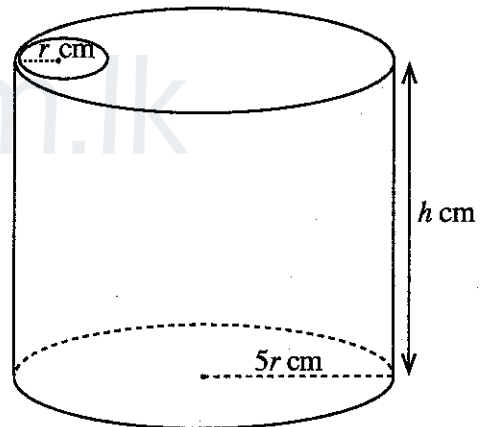
Write down the equations of the asymptotes of $y = f(x)$.

Find the coordinates of the point at which the horizontal asymptote intersects the curve $y = f(x)$.

Sketch the graph of $y = f(x)$ indicating the asymptotes and the turning points.

(b) A thin metal container, in the shape of a right circular cylinder of radius $5r$ cm and height h cm has a circular lid of radius $5r$ cm with a circular hole of radius r cm. (See the figure.) The volume of the container is given to be 245π cm³. Show that the surface area S cm² of the container with the lid containing the hole is given by $S = 49\pi \left(r^2 + \frac{2}{r} \right)$ for $r > 0$.

Find the value of r such that S is minimum.



15.(a) (i) Find $\int \frac{dx}{\sqrt{3+2x-x^2}}$.

(ii) Find $\frac{d}{dx} \left(\sqrt{3+2x-x^2} \right)$ and hence, find $\int \frac{x-1}{\sqrt{3+2x-x^2}} dx$.

Using the above integrals, find $\int \frac{x+1}{\sqrt{3+2x-x^2}} dx$.

(b) Express $\frac{2x-1}{(x+1)(x^2+1)}$ in partial fractions and hence, find $\int \frac{(2x-1)}{(x+1)(x^2+1)} dx$.

(c) (i) Let $n \neq -1$. Using integration by parts, find $\int x^n (\ln x) dx$.

(ii) Evaluate $\int_1^3 \frac{\ln x}{x} dx$.

[see page nine

16.(a) The equation of the diagonal AC of a rhombus $ABCD$ is $3x - y = 3$ and $B \equiv (3, 1)$. Also, the equation of CD is $x + ky = 4$, where k is a real constant. Find the value of k and the equation of BC .

(b) Sketch the circles, C_1 and C_2 given by the equations $x^2 + y^2 = 4$ and $(x-1)^2 + y^2 = 1$ respectively, indicating clearly their point of contact.

A circle C_3 touches C_1 internally and C_2 externally. Show that the centre of C_3 lies on the curve $8x^2 + 9y^2 - 8x - 16 = 0$.

17.(a) Write down the trigonometric identity for $\tan(\alpha + \beta)$ in terms of $\tan \alpha$ and $\tan \beta$.

Hence, obtain $\tan 2\theta$ in terms of $\tan \theta$, and show that $\tan 3\theta = \frac{3 \tan \theta - \tan^3 \theta}{1 - 3 \tan^2 \theta}$.

By substituting $\theta = \frac{5\pi}{12}$ in the last equation, verify that $\tan \frac{5\pi}{12}$ is a solution of $x^3 - 3x^2 - 3x + 1 = 0$.

Given further that $x^3 - 3x^2 - 3x + 1 = (x+1)(x^2 - 4x + 1)$, deduce that $\tan \frac{5\pi}{12} = 2 + \sqrt{3}$.

(b) Show that $\tan^2 \frac{A}{2} = \frac{1 - \cos A}{1 + \cos A}$ for $0 < A < \pi$.

In the usual notation, using the Cosine Rule for a triangle ABC , show that

$$(a+b+c)(b+c-a) \tan^2 \frac{A}{2} = (a+b-c)(a+c-b).$$

(c) Show that $\sin^{-1} \left(\frac{3}{5} \right) + \sin^{-1} \left(\frac{5}{13} \right) = \sin^{-1} \left(\frac{56}{65} \right)$.



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සංයුක්ත ගණිතය II இணைந்த கணிதம் II Combined Mathematics II	10 E II	පැය තුනයි மூன்று மணித்தியாலம் Three hours
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Index Number									
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- * You are permitted to remove **only Part B** of the question paper from the Examination Hall.
- * In this question paper, *g* denotes the acceleration due to gravity.

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(10) Combined Mathematics II		
Part	Question No.	Marks
A	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
B	11	
	12	
	13	
	14	
	15	
	16	
	17	
Total		
Percentage		

Paper I	
Paper II	
Total	
Final Marks	

Final Marks

In Numbers	
In Words	

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Marking Examiner	
Checked by:	1
	2
Supervised by:	

[see page two

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 සහතික පොතේ තුනවන පத்திர (உயர் தர) பரீட்சை, 2016 ஆகஸ்ட்
 General Certificate of Education (Adv. Level) Examination, August 2016

සංයුක්ත ගණිතය II
 இணைந்த கணிதம் II
 Combined Mathematics II

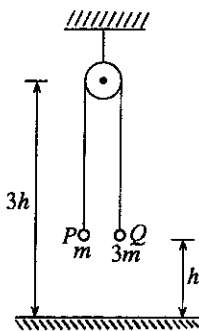
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PART B

* Answer five questions only.

(In this question paper, g denotes the acceleration due to gravity.)

11. (a) A particle P of mass m is connected to a particle Q of mass $3m$ by a light inextensible string passing over a small smooth pulley fixed at a height $3h$ above an inelastic horizontal floor. Initially the two particles are held at a height h above the floor with the string taut, and released from rest. (See the adjoining figure.) Applying Newton's second law separately to the motions of P and Q , show that the magnitude of acceleration of each particle is $\frac{g}{2}$.

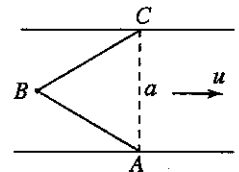


After a time t_0 the particle Q strikes the floor, comes to rest instantly, remains at rest for a further time t_1 and begins to move up. Sketch the velocity-time graphs separately for the motions of the two particles P and Q until the particle Q begins to move up.

Using these graphs, show that $t_0 = 2\sqrt{\frac{h}{g}}$ and find t_1 in terms of g and h .

Show further that the particle P reaches a maximum height $\frac{5h}{2}$ above the floor.

(b) A straight river of breadth a flows with uniform speed u . The points A and C are situated on opposite banks of the river such that the line AC is perpendicular to the direction of flow of the river. Also, a stationary buoy B is fixed in the middle of the river, on the upstream side of AC such that ABC is an equilateral triangle. (See the adjoining figure.)

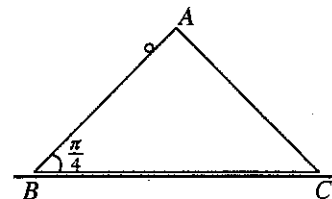


A boat moving with speed v ($> u$) relative to water starts off from A and moves until it reaches B . Then it moves from B to C . Sketch the velocity triangles for the motions of the boat from A to B and from B to C .

Show that the speed of the boat in its motion from A to B is $\frac{1}{2}(\sqrt{4v^2 - u^2} - \sqrt{3}u)$ and find its speed in the motion from B to C .

Hence, show that the total time taken by the boat for the paths AB and BC is $\frac{a\sqrt{4v^2 - u^2}}{v^2 - u^2}$.

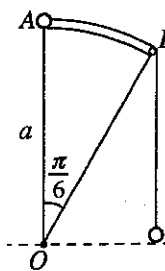
12. (a) The triangle ABC in the figure is a vertical cross-section through the centre of gravity of a uniform wedge of mass $2m$. The line AB is a line of greatest slope of the face containing it and $\hat{ABC} = \frac{\pi}{4}$. The wedge is placed with the face containing BC on a rough horizontal floor. The face containing AB is smooth. A particle of mass m is held on AB as in the figure and the system is released from rest. It is given that the wedge moves in the direction of \vec{BC} and that



the magnitude of the frictional force exerted on the wedge by the floor is $\frac{R}{6}$, where R is the magnitude of the normal reaction exerted on the wedge by the floor. Obtain equations which are sufficient to determine R , in terms of m and g .

[see page eight]

- (b) OAB in the figure is a circular sector of radius a subtending an angle $\frac{\pi}{6}$ at the centre O with OA vertical. It is a cross-section perpendicular to the axis of a smooth cylindrical sector fixed with its axis horizontal. One end of a light inextensible string passing over a small smooth pulley fixed at B is attached to a particle P of mass $3m$ and the other end is attached to a particle Q of mass m . Initially, the particle P is held at A and the particle Q hangs freely at the horizontal level of O . The system is released from rest in this position, with the string taut. When OP makes an angle θ ($0 < \theta < \frac{\pi}{6}$) with the upward vertical, show that $2a\dot{\theta}^2 = 3g(1 - \cos \theta) + g\theta$ and that the tension in the string is $\frac{3}{4}mg(1 - \sin \theta)$, and find the normal reaction on the particle P .



13. One end of a light elastic string of natural length a and modulus of elasticity $4mg$ is tied to a fixed point O and the other end to a particle P of mass m . The particle P is released from rest at O . Find the velocity of the particle P when it passes through the point A , where $OA = a$.

Show that the length of the string x ($x \geq a$) satisfies the equation $\ddot{x} + \frac{4g}{a} \left(x - \frac{5a}{4} \right) = 0$.

Taking $X = x - \frac{5a}{4}$, express the above equation in the form $\ddot{X} + \omega^2 X = 0$, where ω (> 0) is a constant to be determined.

Assuming that $\dot{X}^2 = \omega^2 (c^2 - X^2)$, find the amplitude c of this simple harmonic motion.

Let L be the lowest point reached by the particle P . Show that the time taken by P to move from A to L is $\frac{1}{2} \sqrt{\frac{a}{g}} \left\{ \pi - \cos^{-1} \left(\frac{1}{3} \right) \right\}$.

At the instant when the particle P is at L , another particle of mass λm ($1 \leq \lambda < 3$) is gently attached to P . Show that the equation of motion of the composite particle of mass $(1 + \lambda)m$ is $\ddot{x} + \frac{4g}{(1 + \lambda)a} \left\{ x - (5 + \lambda) \frac{a}{4} \right\} = 0$.

Show further that the composite particle performs complete simple harmonic motion with amplitude $(3 - \lambda) \frac{a}{4}$.

14. (a) The position vectors of two points A and B with respect to an origin O are \mathbf{a} and \mathbf{b} respectively, where O , A and B are **not collinear**. Let C be the point such that $\overrightarrow{OC} = \frac{1}{3} \overrightarrow{OB}$ and let D be the point such that $\overrightarrow{OD} = \frac{1}{2} \overrightarrow{AB}$. By expressing \overrightarrow{AC} and \overrightarrow{AD} in terms of \mathbf{a} and \mathbf{b} , show that $\overrightarrow{AD} = \frac{3}{2} \overrightarrow{AC}$.

Let P and Q be the points on AB and OD respectively, such that $\overrightarrow{AP} = \lambda \overrightarrow{AB}$ and $\overrightarrow{OQ} = (1 - \lambda) \overrightarrow{OD}$, where $0 < \lambda < 1$. Show that $\overrightarrow{PC} = 2 \overrightarrow{CQ}$.

- (b) In a parallelogram $ABCD$, let $AB = 2$ m and $AD = 1$ m, and let $\hat{BAD} = \frac{\pi}{3}$. Also, let E be the mid-point of CD . Forces of magnitudes 5, 5, 2, 4 and 3 newtons act along AB , BC , DC , DA and BE respectively, in the directions indicated by order of the letters. Show that their resultant force is parallel to \overrightarrow{AE} , and find its magnitude.

Also, show that the line of action of the resultant force meets AB produced at a distance $\frac{3}{2}$ m from B .

An additional force acting through C is now added to the above system of forces so that the resultant force of the new system is along \overrightarrow{AE} . Find the magnitude and direction of the additional force.

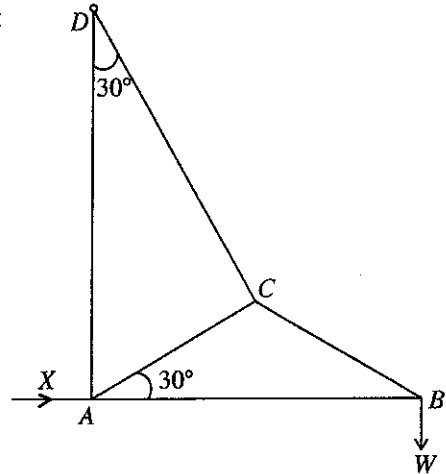
[see page nine

15. (a) Four equal uniform rods, each of weight w_1 , are smoothly jointed at their ends to form a rhombus $ABCD$. The mid-points of BC and CD are connected by a light rod such that $\hat{B}AD = 2\theta$. Each of the joints B and D carries equal loads of weight w_2 . The system, hanging symmetrically from the joint A , is in equilibrium in a vertical plane with the light rod horizontal. Show that the thrust in the light rod is $2(2w_1 + w_2) \tan \theta$.

(b) The adjoining figure represents a framework of five light rods AB, BC, CD, AC and AD , smoothly jointed at the ends. It is given that $AC = CB$ and $\hat{B}AC = 30^\circ = \hat{A}DC$. The framework is smoothly hinged at D . A weight W is suspended at the joint B and the framework is kept in equilibrium in a vertical plane with AB horizontal and AD vertical, by a horizontal force of magnitude X acting at A .

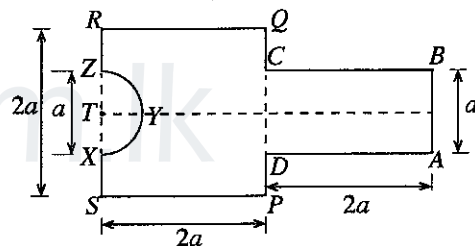
Using Bow's notation, draw stress diagrams for the joints B, C and A in the same figure.

Hence, find the value of X and the stresses in all rods, distinguishing between tensions and thrusts.

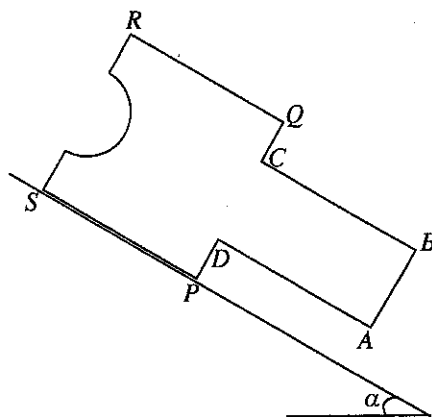


16. Show that the centre of mass of a uniform semi-circular lamina of radius r and centre O is at a distance $\frac{4r}{3\pi}$ from O .

As shown in the adjoining figure, a uniform plane lamina L is made by rigidly attaching a rectangle $ABCD$ to a square $PQRS$ such that DC and PQ lie on the same line with their mid-points coinciding, and removing a semi-circular region XYZ of radius $\frac{a}{2}$ centred at the mid-point T of RS . It is given that $AB = a$ and $AD = PQ = 2a$. Show that the centre of mass of the lamina L lies on the axis of symmetry at a distance ka from RS , where $k = \frac{238}{3(48 - \pi)}$.



As shown in the adjoining figure, the lamina L is in equilibrium on a rough plane inclined at an angle α to the horizontal with its plane vertical and the edge PS on a line of greatest slope such that the point P lies below S . Show that $\tan \alpha < (2 - k)$ and $\mu \geq \tan \alpha$, where μ is the coefficient of friction between the lamina and the inclined plane.



[see page ten

17.(a) An unbiased cubical die A shows 1, 2, 3, 3, 4, 5 on its six separate faces. The die A is tossed twice. Find the probability that the sum of the two numbers obtained is 6.

Another die B , identical to A in all respects except for the numbers on the faces, shows 2, 2, 3, 4, 4, 5 on its six separate faces. The die B is tossed twice. Find the probability that the sum of the two numbers obtained is 6.

Now, the two dice A and B are put in a box. One die is taken out of the box at random and tossed twice. Given that the sum of the two numbers obtained is 6, find the probability that the die taken out of the box is the die A .

(b) The mean and the standard deviation of n numbers x_1, x_2, \dots, x_n are μ_1 and σ_1 respectively, and the mean and the standard deviation of m numbers y_1, y_2, \dots, y_m are μ_2 and σ_2 respectively. Let the mean and the standard deviation of all of these $n + m$ numbers be μ_3 and σ_3 respectively.

Show that
$$\mu_3 = \frac{n\mu_1 + m\mu_2}{n + m}.$$

Let $d_1 = \mu_3 - \mu_1$. Show that
$$\sum_{i=1}^n (x_i - \mu_3)^2 = n(\sigma_1^2 + d_1^2).$$

By taking $d_2 = \mu_3 - \mu_2$, write down a similar expression for
$$\sum_{j=1}^m (y_j - \mu_3)^2.$$

Deduce that
$$\sigma_3^2 = \frac{(n\sigma_1^2 + m\sigma_2^2) + (nd_1^2 + md_2^2)}{n + m}.$$

The number of copies sold per day, during the first 100 days after publishing a new book, had mean 2.3 and variance 0.8. During the next 100 days, the number of copies sold per day had mean 1.7 and variance 0.5. Find the mean and the variance of the number of copies sold per day during the first 200 days.
