# Three-dimensional Geometry

Standard difficulty · 20 questions · 40 marks · Time: 42 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

## Section A — Choose the correct answer 8 × 1 = 8 marks

**1.** The direction cosines of a line with direction ratios 3, 2, −6 are:
**(a)** 3/7, 2/7, −6/7 **(b)** 3/49, 2/49, −6/49
**(c)** 3/11, 2/11, −6/11 **(d)** 2/7, 3/7, −6/7

**2.** The direction ratios of the line through (−2, −5, 4) and (−4, −4, −1) are:
**(a)** −2, −5, 4 **(b)** 1, −2, −5 **(c)** −6, −9, 3 **(d)** −2, 1, −5

**3.** The Cartesian equation of the line through (5, 2, 5) with direction ratios −3, −3, 3 is:
**(a)** (x − 6)/(−3) = (y − 2)/(−3) = (z − 5)/3 **(b)** (x + 5)/(−3) = (y + 2)/(−3) = (z + 5)/3
**(c)** (x + 3)/5 = (y + 3)/2 = (z − 3)/5 **(d)** (x − 5)/(−3) = (y − 2)/(−3) = (z − 5)/3

**4.** The angle between lines with direction ratios −6, 3, 2 and −9, −8, −12 is:
**(a)** $\sin^{-1}(6/119)$ **(b)** $\cos^{-1}(1/21)$ **(c)** $\cos^{-1}(6/119)$ **(d)** π/2

**5.** The direction cosines of the x-axis are:
**(a)** 1, 0, 0 **(b)** 1, 1, 1 **(c)** 0, 1, 0 **(d)** 0, 0, 1

**6.** A line has direction cosines l = 12/13, m = 4/13 and n. Then n is:
**(a)** ±3/169 **(b)** ±−3/13 **(c)** ±9/169 **(d)** ±3/13

**7.** The point on the line $\vec{r} = (2\hat{i} - 3\hat{j} + 2\hat{k}) + \lambda(2\hat{i} + \hat{j} + 4\hat{k})$ for λ = 2 is:
**(a)** (6, −1, 10) **(b)** (6, −5, 8) **(c)** (8, 0, 14) **(d)** (−2, −5, −6)

**8.** Assertion (A): The lines with direction ratios 6, 5, 5 and −15, −11, 29 are perpendicular.
Reason (R): The direction cosines l, m, n of a line satisfy $l^2 + m^2 + n^2 = 1$.
**(a)** Both A and R are true, and R is the correct explanation of A.
**(b)** Both A and R are true, but R is not the correct explanation of A.
**(c)** A is true, but R is false.
**(d)** A is false, but R is true.

## Section B — Short answer 8 × 2 = 16 marks

**9.** Find the vector and Cartesian equations of the line through (−2, −4, 4) and (−5, 3, −1).

**10.** Find the angle between the lines (x − 3)/(−12) = (y + 1)/12 = (z + 4)/1 and (x − 1)/(−11) = (y − 5)/(−2) = (z + 3)/10.

**11.** Find the distance between the parallel lines $\vec{r} = (\hat{i} - 5\hat{j} - 4\hat{k}) + \lambda(-8\hat{i} - 4\hat{j} + \hat{k})$ and $\vec{r} = (\hat{i} - 4\hat{j} - 5\hat{k}) + \mu(-8\hat{i} - 4\hat{j} + \hat{k})$.

**12.** Find the shortest distance between the lines $\vec{r} = (3\hat{i} - \hat{j} + 2\hat{k}) + \lambda(\hat{i} + 3\hat{j} - 4\hat{k})$ and $\vec{r} = (-\hat{i} + 3\hat{j} - 3\hat{k}) + \mu(-\hat{i} + 4\hat{j} - 2\hat{k})$.

**13.** Find k so that the lines $(x - 5)/k = (y + 3)/(-5) = (z + 5)/(-5)$ and $(x - 5)/(-4) = (y - 3)/(-5) = (z + 5)/(-6)$ are perpendicular.

**14.** Find the foot of the perpendicular from P(−6, 0, 1) to the line $\vec{r} = (2\hat{i} + 5\hat{j} - 2\hat{k}) + \lambda(4\hat{i} - \hat{j} - 5\hat{k})$.

**15.** Find the direction cosines of the line joining (−3, −1, 2) and (1, −13, −1).

**16.** Write the line $(x - 2)/(-4) = (y - 1)/(-5) = (z + 1)/1$ in vector form.

## Section C — Word problems — 4 × 4 = 16 marks

**17.** Find the shortest distance between the lines $\vec{r} = (-3\hat{j} - \hat{k}) + \lambda(4\hat{i} + 4\hat{j} - 6\hat{k})$ and $\vec{r} = (-\hat{i} - 4\hat{j} - 3\hat{k}) + \mu(-\hat{i} - 2\hat{j} + 6\hat{k})$.

**18.** Find the foot of the perpendicular from P(25, 8, −6) to the line $(x - 3)/5 = (y + 2)/5 = (z + 4)/(-6)$, the length of the perpendicular, and the image of P in the line.

**19.** Show that the lines $(x + 6)/1 = (y - 2)/(-2) = (z + 4)/1$ and $(x + 15)/6 = (y + 16)/6 = (z - 9)/(-5)$ intersect, and find the point of intersection.

**20.** Find the vector and Cartesian equations of the line through (−5, −4, −2) parallel to $\vec{r} = (-\hat{i} + \hat{j} - 5\hat{k}) + \lambda(-4\hat{i} + 8\hat{j} + \hat{k})$, and the distance between the two lines.

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# Answer key

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| Q | Answer | Working |
|---|---|---|
| 1 | **(a) 3/7, 2/7, −6/7** | divide each by $\sqrt{(3^2 + 2^2 + (-6)^2)} = 7$ |
| 2 | **(d) −2, 1, −5** | subtract the coordinates |
| 3 | **(d) (x − 5)/(−3) = (y − 2)/(−3) = (z − 5)/3** | $(x - x_1)/a = (y - y_1)/b = (z - z_1)/c$ |
| 4 | **(c) $\cos^{-1}(6/119)$** | $\cos\theta = \lvert 6\rvert/(7 \times 17)$ |
| 5 | **(a) 1, 0, 0** | — |
| 6 | **(d) ±3/13** | $n^2 = 1 - l^2 - m^2 = 9/169$ |
| 7 | **(a) (6, −1, 10)** | (2, −3, 2) + 2(2, 1, 4) |
| 8 | **(b) Both A and R are true, but R is not the correct explanation of A.** | A is true: $a_1a_2 + b_1b_2 + c_1c_2 = 0$. R is true but does not explain A. |
| 9 | **$\vec{r} = (-2\hat{i} - 4\hat{j} + 4\hat{k}) + \lambda(-3\hat{i} + 7\hat{j} - 5\hat{k})$; (x + 2)/(−3) = (y + 4)/7 = (z − 4)/(−5)** | direction (−3, 7, −5) |
| 10 | **$\theta = \cos^{-1}(118/255)$** | $\cos\theta = \lvert 118\rvert/(17 \times 15)$ |
| 11 | **(1/9)√137** | $\lvert b \times (a_2 - a_1)\rvert/\lvert b\rvert = \sqrt{137}/9$ |
| 12 | **(51/185)√185** | $b_1 \times b_2 = 10\hat{i} + 6\hat{j} + 7\hat{k}$; $\lvert(a_2 - a_1) \cdot (b_1 \times b_2)\rvert = 51$; distance = 51/√185 |
| 13 | **k = 55/4** | (−4)k + (−5)(−5) + (−5)(−6) = 0 |
| 14 | **(−2, 6, 3)** | a general point is (2, 5, −2) + λ(4, −1, −5); (point − P) · b = 0 gives λ = −1 |
| 15 | **4/13, −12/13, −3/13** | direction ratios 4, −12, −3; length 13 |
| 16 | **$\vec{r} = (2\hat{i} + \hat{j} - \hat{k}) + \lambda(-4\hat{i} - 5\hat{j} + \hat{k})$** | read off the point and the direction ratios |
| 17 | **7/11** | $a_2 - a_1 = -\hat{i} - \hat{j} - 2\hat{k}$; $b_1 \times b_2 = 12\hat{i} - 18\hat{j} - 4\hat{k}$; distance = $\lvert(a_2 - a_1) \cdot (b_1 \times b_2)\rvert/\lvert b_1 \times b_2\rvert = 14/\sqrt{484}$ |
| 18 | **foot (13, 8, −16); length 2√61; image (1, 8, −26)** | λ = 2; the image is 2 × foot − P |
| 19 | **(−3, −4, −1)** | general points (−6, 2, −4) + λ(1, −2, 1) and (−15, −16, 9) + μ(6, 6, −5) agree for λ = 3, μ = 2 |
| 20 | **$\vec{r} = (-5\hat{i} - 4\hat{j} - 2\hat{k}) + \mu(-4\hat{i} + 8\hat{j} + \hat{k})$; (x + 5)/(−4) = (y + 4)/8 = (z + 2)/1; distance (1/3)√401** | $\lvert b \times (P - a)\rvert/\lvert b\rvert = \sqrt{3609}/9$ |



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