436-105 ENGINEERING COMMUNICATIONS

Student Number: ………………..

Examination duration: 3 hours
Reading time: 15 minutes
This paper has: 8 pages

Authorised materials:
Electronic calculators and drawing instruments may be used.

Instructions to invigilators:
Candidates are to complete the examination by writing and drawing in this examination paper, which must be collected at the end of the examination. No additional script books should be required.

Instructions to students:
Attempt all of the five questions. All questions are of equal value.
Space is provided in this paper to complete all the questions. No additional script books should be required. The whole paper must be left for collection by the invigilators at the end of the examination.
Be sure to write your student number in the space provided above.

Library:
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Question 1

(a) Multiview drawings of four different solid objects are shown in figure 1(a), labelled 1 to 4. Beside each multiview drawing are pictorial views of four solid objects, labelled A to D, one of which is correctly represented by the multiview drawing. For each case 1 to 4 indicate, by circling the appropriate letter, which object is correctly represented.

Figure 1 (a)
Question 1 (continued)

(b) In each of figures 1 (b) and (c), two complete and correct orthogonal views of an object are sketched. In each case, complete the missing third view, using the identified corner.
Question 2
Make an isometric sketch of the object represented by multiview drawings in each of figures 2 (a) and (b).

Figure 2 (a)

Figure 2 (b)

Question 3
Figure 3 shows a plan and front elevation of part of a chemical plant. Operating staff regularly use an elevated walkway which is near a spherical cryogenic tank containing liquefied gases at low temperature (for example, to access inspection points A and B).

(a) Determine graphically the position of the point P on the surface of the sphere closest to the handrail on the walkway. What is the shortest distance from the handrail to the tank?

(b) Show on the front elevation the position of the circles of longitude and latitude which pass through P.

(Note: On the earth’s surface circles of longitude run from North to South, and circles of latitude run from East to West.)
Figure 3

SD = 6.03 m
Question 4

Make a fully-dimensioned multiview drawing of the anchor clip depicted in figure 4, showing sufficient views to fully describe its shape.
Question 5
Consider the problem introduced in question 3, and illustrated again in figure 5. Use vector methods to determine:

(a) the position of the point P on the surface of the sphere closest to the handrail on the walkway,
(b) the shortest distance from the handrail to the tank.

Hints:
1. Introduce an x-y-z coordinate system with its origin at the centre of the spherical tank.
2. Recall that the vector equation for a straight line is \( \mathbf{r} = \mathbf{r}_0 + \lambda \mathbf{u} \), where \( \mathbf{r}_0 \) is the position vector of a known point on the line, \( \mathbf{u} \) is a unit vector in the direction of the line, and \( \lambda \) is a scalar distance.
3. The dot product of perpendicular vectors evaluates to zero.
Worksheet for question 5

Strategy:
(i) Get equation for point $M$ on line representing handrail
(ii) Define equation for point $N$ on radial line from centre of tank
(iii) Equate these to get equation for intersection point $Q = M = N$
(iv) Constrain radial line to be perpendicular to handrail

Solution:
(i) A point on handrail is $O$: $\mathbf{r}_O = (-5, -8, -4)$ -- see diagram on previous page.
Unit vector in direction of handrail is $\mathbf{u} = (-0.7071, 0.7071, 0)$
Hence equation for general point $M$ on handrail is $\mathbf{r}_M = \mathbf{r}_O + \lambda \mathbf{u}$
(ii) Let unit radial vector be $\mathbf{v}$.
Then, equation for general point $N$ on radial line is $\mathbf{r}_N = \mathbf{r}_O \mathbf{v}$
(iii) Handrail and radial line intersect at $Q = M = N$:
$\mathbf{r}_Q = \mathbf{r}_O + \lambda \mathbf{u} = \mathbf{r}_N \mathbf{v}$
(iv) But $\mathbf{u}$ and $\mathbf{v}$ must be perpendicular, so that $\mathbf{u} \cdot \mathbf{v} = 0$.
Hence, $\mathbf{r}_Q \cdot \mathbf{u} = \mathbf{r}_O \cdot \mathbf{u} + \lambda = 0$.
\[\text{i.e., } (-5, -8, -4) \cdot (-0.7071, 0.7071, 0) + \lambda = 0 \implies \lambda = 2.121\]
That is, intersection point is 2.121 m along handrail from $O$.
Hence, $\mathbf{r}_Q = \mathbf{r}_O + \lambda \mathbf{u} = (-5, -8, -4) + 2.121(-0.7071, 0.7071, 0)$
\[\text{i.e., } \mathbf{r}_Q = (-6.5, -6.5, -4)\]
Now, require $N = Q$, so that $\mathbf{r}_N = \mathbf{r}_Q = (-6.5, -6.5, -4)$
Hence unit vector $\mathbf{v}$ can be found as $\mathbf{v} = \mathbf{r}_N / |\mathbf{r}_N|$
\[\text{i.e., } \mathbf{v} = (-0.648, -0.648, -0.399)\]
Thus, position of point $P$ on surface (radial distance $r = 4$ m) is:
$\mathbf{r}_P = 4\mathbf{v} = (-2.594, -2.594, -1.596)$ (a)

Now, shortest distance $SD = |\mathbf{r}_Q - \mathbf{r}_P| = |(-3.907, -3.907, -2.404)|$
Hence, $SD = 6.025$ m (b)