L-4/T-1/IPE Date: 25/08/2025

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2023-2024

Sub: **IPE 317** (Product Design II)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

Shigley's Mechanical Engineering Design (11th edition) book will be supplied.

Assume any Missing Value.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer to **Q. No. 1 is COMPULSORY**.

Answer any **TWO** questions from Question 2-4.

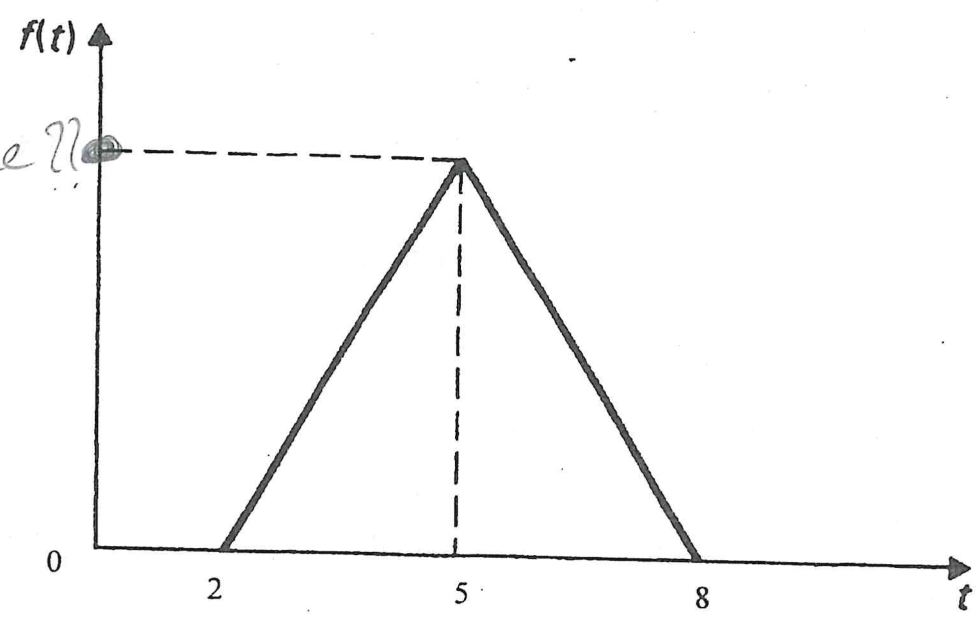
1. (a) Design a straight-bevel gear mesh for shaft centerlines that intersect perpendicularly. The uncrowned straight-bevel pinion has 22 teeth, a module of 4 mm, and a transmission accuracy number of 5. The pinion and the gear are made of through-hardened steel, both having a core and case hardness of 180 Brinell. The pinion drives the 24-tooth bevel gear. The pinion speed is 1800 rev/min, the face width is 25 mm, and the normal pressure angle is 20°. Both gears have an outboard mounting. Find the power rating based on AGMA pitting resistance if the life goal is 10^9 revolutions of the pinion at 0.999 reliability. **(20)** (CO1)

(b) Identify a 02-series single-row deep-groove ball bearing for the application conditions specified in the following table. **(15)** (CO3)

Radial Load	Axial Load	Design Life	Ring rotating	Desired Reliability
10 kN	5 kN	12 kh, 300 rev/min	Inner	95%

Specify the smallest bore size that can satisfy these conditions.

2. (a) **(10)**



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Contd.... for Q. No. 2(a)

From the above figure find

(i) PDF

(ii) CDF

(iii) 95th percentile value

(b) The capacity of an isolated spread footing foundation under a column is modeled by a normal distribution with a mean of 300 kip and a COV of 20%. Suppose the column is subjected to dead load of 100 kip and a live load of 150 kip. **(15)**

(i) Calculate the probability of failure of the foundation under dead load only.

(ii) Calculate the probability of failure of the foundation under the combined action of dead and live loads.

(iii) If the probability of failure of the foundation needs to be limited to 0.001, and the dead load of 100 kip cannot be changed, what is the maximum amount of live load that can be applied to the foundation?

(c) The mean compressive strength of a batch of concrete is 5,000 psi with a standard deviation of 500 psi. The magnitude of stress acting on the structure can be modeled with a mean of 1000 psi and a standard deviation of 200 psi. **(10)**

(i) Find reliability of the system when both strength and stress follow exponential distribution

(ii) Find reliability of the system when both strength and stress follow normal distribution

(iii) Find reliability of the system when both strength and stress follow log-normal distribution.

3. (a) A full journal bearing is 28 mm long. The shaft journal has a diameter of 56 mm with a unilateral tolerance of –0.012 mm. The bushing bore has a diameter of 56.05 mm with a unilateral tolerance of 0.012 mm. The load is 2.4 kN and the journal speed is 900 rev/min. The lubricating oil is SAE 30 supplied at 45°C. For the minimum clearance assembly find **(20)**

(i) Magnitude and location of the minimum oil-film thickness

(ii) Eccentricity

(iii) Coefficient of friction

(iv) Total and side flowrates

(v) Maximum oil-film pressure and its angular location

(b) Two ball bearings from different manufactures are being considered for a certain application. Bearing A has a catalog rating of 2.0 kN based on a catalog that rates at 10^6 cycles. For a given application, determine which bearing can carry the larger load. **(15)**

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4. (a) A 20° spur pinion with 20 teeth and a module of 2.5 mm transmits 120 W to a 36-tooth gear. The pinion speed is 100 rev/min, and the gears are grade 1, 18-mm face width, through-hardened steel at 200 Brinell, uncrowned, manufactured to a No. 6 quality standard, and considered to be of open gearing quality installation. Find the AGMA bending and contact stresses and the corresponding factors of safety for a pinion life of 10^8 cycles and a reliability of 0.95. **(20)**

(b) Design a friction metal flat-belt drive to connect a 5 kW, four-pole squirrel-cage motor turning at 1750 rev/min to a shaft 381 mm away, running at half speed. The circumstances are such that a service factor of 1.2 and a design factor of 1.05 are appropriate. The life goal is 10^6 belt passes, f = 0.35, and the environmental considerations require a stainless-steel belt. **(15)**

SECTION – B

There are **FOUR** questions in this section. Answer to **Q. No. 5 is COMPULSORY.**
Answer any **TWO** questions from Question 6-8.

5. (a) As a product designer, explain how design choices, manufacturing methods, and supply chain logistics for **a smart board**, influence its cost-efficiency and functional utility. Extend you analysis by including DFM decisions. **(20)** (CO2)

(b) Set DFE goals for **a typical ceiling fan** producing company, based on its product's life cycle stages. **(15)** (CO4)

6. (a) Justify the statement— "The choice of survey format is closely linked to the way in which the concept will be communicated." **(10)**

(b) Discuss some applications of computer-aided design software in product design. **(10)**

(c) How did you approach the step called "Clarifying the Problem", while generating concepts for your respective product of the corresponding sessional course? **(15)**

7. (a) How might you use the concept selection method to decide whether to offer a single product to the marketplace or to offer several different product options? **(10)**

(b) How break-even analysis can be used as a product screening tool? **(10)**

(c) Differentiate between various types of prototypes. **(15)**

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8. (a) A speed-reducer gearbox containing a compound reverted gear train transmits 26.09 kW with an input speed of 1200 rev/min. Spur gears with 20° pressure angle are used, with 16 teeth on each of the small gears and 48 teeth on each of the larger gears. A diametral pitch of 10 teeth/in is proposed. **(25)**

   (i) Determine the speeds of the intermediate and output shafts.

   (ii) Determine the pitch line velocities (mm/min) for each set of gears.

   (iii) Determine the magnitudes of the tangential, radial, and total forces transmitted between each set of gears.

   (iv) Determine the input torque.

   (v) Determine the output torque, neglecting frictional losses.

(b) The maximum band interface pressure on the brake shown in Figure 8(b) is 620 kPa. Use a 350 mm-diameter drum, a band width of 25 mm, a coefficient of friction of 0.30, and an angle-or-wrap of 270°. Find the maximum band tensions at the hinged and open ends. Also, determine the torque capacity. **(10)**

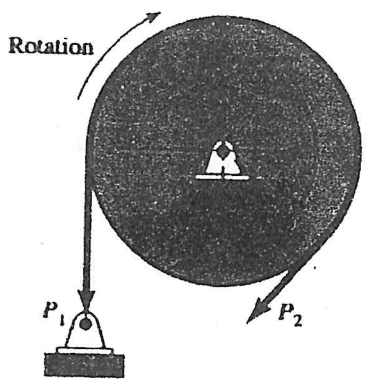

Figure 8(b)

Course Outcomes of IPE 317

CO No.	CO Statement	Corresponding PO(s)*
CO1	Design machine systems to ensure appropriate functionality of product	PO3
CO2	Explain the impact of utility and cost in design, manufacturing and maintenance	PO2
CO3	Identify the optimum design solution of using engineering and conceptual methods	PO1
CO4	Analyse the product-market fit and sustainability of a product in real life scenarios	PO4

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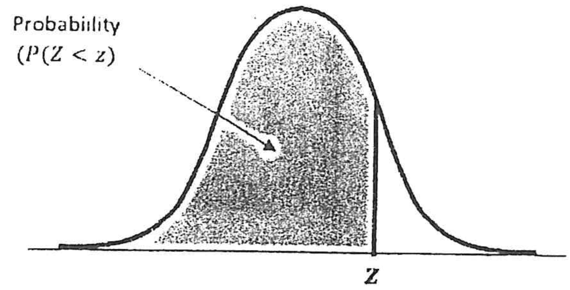
Table 1: Standard Normal Distribution Table for Positive z Score



z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5754
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7258	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7518	0.7549
0.7	0.7580	0.7612	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7996	0.8023	0.8051	0.8079	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9430	0.9441
1.6	0.9452	0.9463	0.9474	0.9485	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9700	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9762	0.9767
2.0	0.9773	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9865	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9980	0.9980	0.9981
2.9	0.9981	0.9982	0.9983	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998	0.9998

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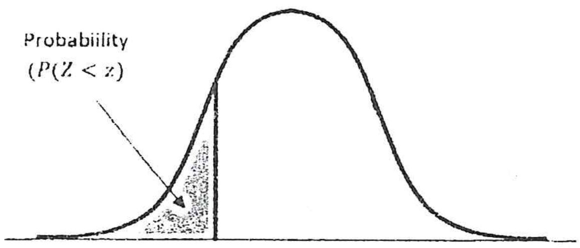
(6)

Table 2: Standard Normal Distribution Table for Negative z Score



z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.00	0.5000	0.4960	0.4920	0.4880	0.4841	0.4801	0.4761	0.4721	0.4681	0.4641
-0.10	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
-0.20	0.4207	0.4168	0.4129	0.4091	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
-0.30	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
-0.40	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
-0.50	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
-0.60	0.2743	0.2709	0.2676	0.2644	0.2611	0.2579	0.2546	0.2514	0.2483	0.2451
-0.70	0.2420	0.2389	0.2358	0.2327	0.2297	0.2266	0.2236	0.2207	0.2177	0.2148
-0.80	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
-0.90	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
-1.00	0.1587	0.1563	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
-1.10	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
-1.20	0.1151	0.1131	0.1112	0.1094	0.1075	0.1057	0.1038	0.1020	0.1003	0.0985
-1.30	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
-1.40	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0722	0.0708	0.0694	0.0681
-1.50	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
-1.60	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
-1.70	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
-1.80	0.0359	0.0352	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
-1.90	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
-2.00	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
-2.10	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
-2.20	0.0139	0.0136	0.0132	0.0129	0.0126	0.0122	0.0119	0.0116	0.0113	0.0110
-2.30	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
-2.40	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0070	0.0068	0.0066	0.0064
2.50	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
-2.60	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
-2.70	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
-2.80	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
-2.90	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
-3.00	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
-3.10	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.20	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
-3.30	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
-3.40	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002

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