First Semester Examination
2020/2021 Academic Session

February 2021

EAH221 – Fluid Mechanics for Civil Engineers

Duration : 3 hours

Please check that this examination paper consists of **TWELVE (12)** pages of printed material including appendix before you begin the examination.

Instructions : This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions.

All questions **MUST BE** answered on a new page.

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1. (a). A manometer is used to measure the pressure between Pipe A and Pipe B as shown in **Figure 1**. The liquid specific gravity for S_1 = 1.5, S_2 = 0.8 and S_3 = 1.3. Determine the pressure difference between Pipe A and Pipe B.

[8 marks]

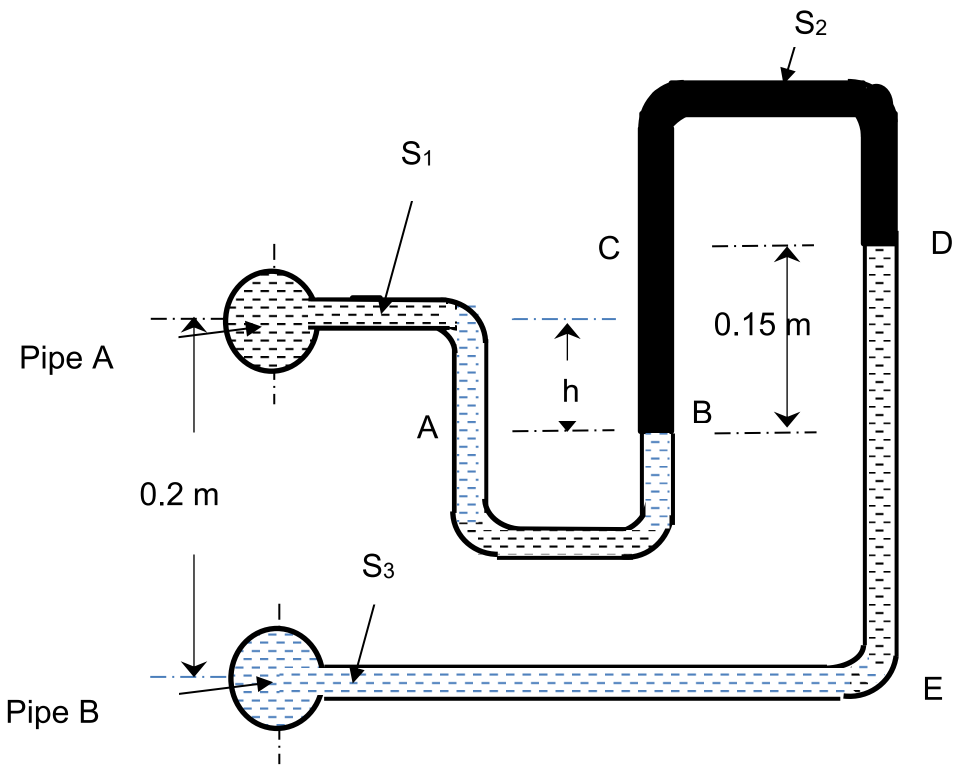


Figure 1

(b). The curved face of a dam is shaped according to the equation $y = \frac{x^2}{12.5}$ as shown in **Figure 2**. For a unit width of the dam, determine the magnitude and direction of the resultant water pressure acting on the curved surface of the dam.

[12 marks]

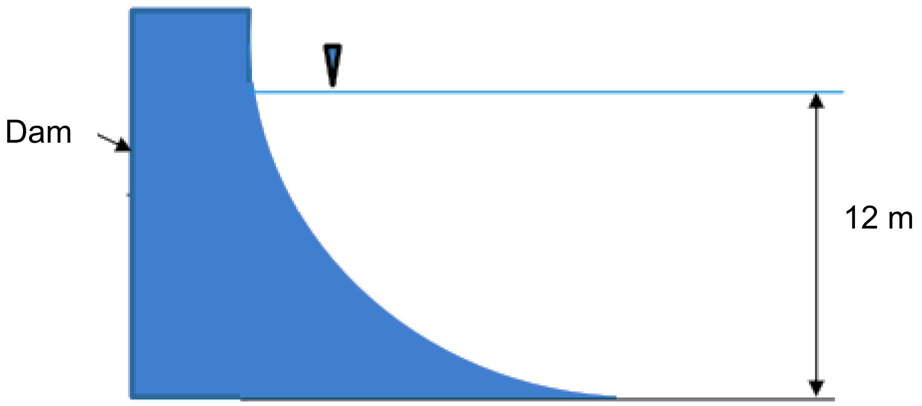


Figure 2

2. (a). A cube of 60 cm side is submerged in a two layer fluid with specific gravity liquid S_1 and S_2, 0.9 and 1.2 respectively, as shown in **Figure 3**. The upper and lower halves of the cube are composed of materials with specific gravity SC_1 and SC_2, 0.6 and 1.4 respectively. Determine the distance of the top of the cube above the fluid interface.

[8 marks]

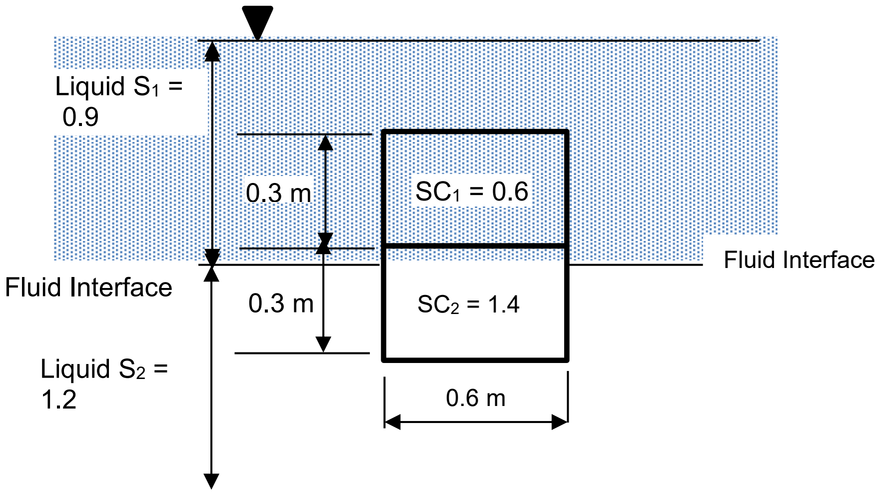


Figure 3

(b). A cylindrical buoy of weight 16.5 kN with diameter 2.4 m and length 2.0 m is floating with its axis vertical in sea water of specific weight 10 kN/m^3 as shown in **Figure 4**. A load of 1.5 kN is placed centrally at the top of the buoy. If the buoy is in stable equilibrium, determine the maximum permissible height h_1, of. the centre of gravity of the load above the top of the buoy.

[12 marks]

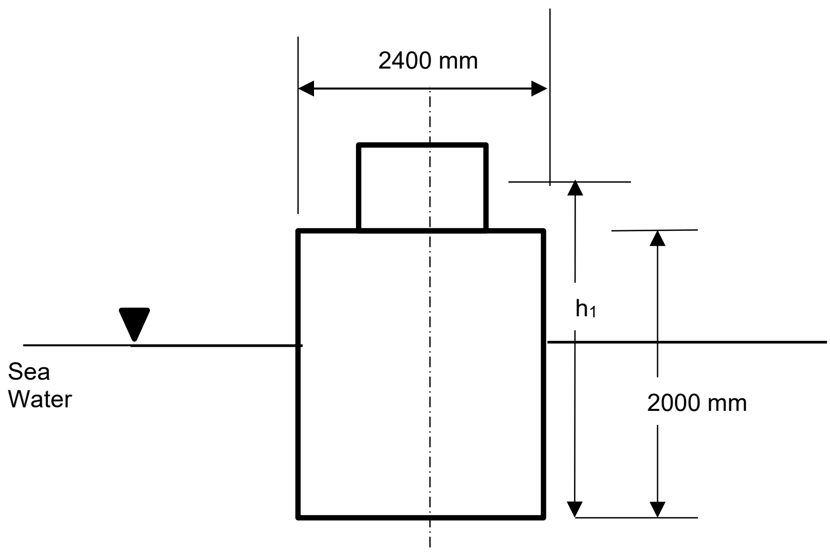


Figure 4

3. (a). A pipe with a diameter of 30 mm carries oil with specific gravity of 0.92 and velocity of 5.5 m/s. The pipe is fitted to another pipe with the radius of 20 mm. (a) Determine the velocity of the pipe at radius of 20 mm and the mass flowrate of the oil. (b) If the dynamic viscosity of oil is 9.6 x 10^{-2} kg m^{-1} s^{-1} flow through at the same pipe, what type of flow will occur?

[8 marks]

(b). Assuming frictionless, incompressible, one-dimensional flow of water through the series pipeline shows in **Figure 5**. The water flow through pipe AB 60 mm in diameter and then pass through BC which is 90 mm in diameter. At C the pipe forks into branch pipe CD and branch pipe CE. The velocity at pipe BC is 2.5 m/s and volume flowrate of branch CD is double than branch CE. Calculate (a) The volume flow rate for pipe AB, BC, CD and CE, (b) The velocity in pipe CE, (c) The diameter of pipe CD.

[12 marks]

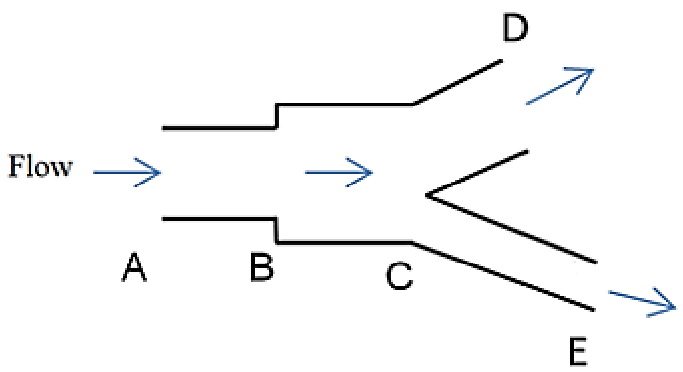


Figure 5: Series Pipeline

4. (a). As shown in **Figure 6**, the water flows down the sloping ramp from Point 1 to Point 2 with negligible viscous efffect. Both flow are uniform at velocity at Point 1 is 0.45 m/s. At upstream depth at Point 1 is 0.25 m and the downstream depth for Point 2 can be determine by using 3 solution derived using Bernoulli dan continuity equation. However, only two solutions are realistic to calculate the value of h_2 and V_2. Determine these values.

[9 marks]

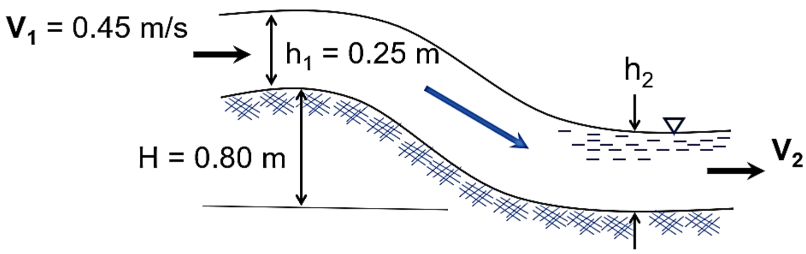


Figure 6: Water flows down sloping ramp

(b). The water is flowing through a tapered pipe of diameters 15 cm and 25 cm at point A and Point B as shown in **Figure 7**. The rate of water flow through the pipe is 35 L/s. At Point A is 3.6 m above datum and at Point B is 7.5 m above datum. If the pressure at Point B is 86 N/cm^2, determine the pressure at Point B.

[11 marks]

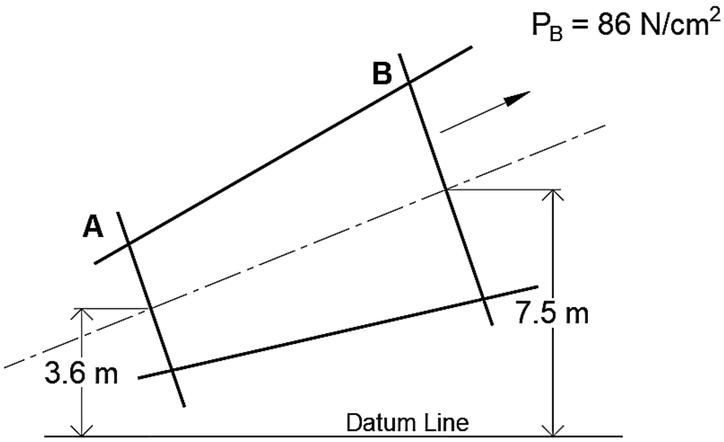


Figure 7: Section of pipe

5. (a). The principle of conservation of momentum states that the momentum of fluid in an isolated system is constant. Consider a jet of water travelling in a smooth rectangular vane at a velocity of 22.5 m/s. The rectangular section is 80 mm wide and 22.5 mm thick. The vane is attached to a rigid foundation at angle shown in **Figure 8**. Determine the vertical and horizontal components of the force exerted on the vane.

[10 marks]

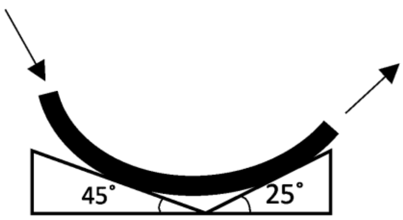


Figure 8

(b). Drag forces are dependent of Reynolds number in order to predict the drag forces experienced by bodies in a fluid. Consider a cylinder 80 mm diameter and 200 mm long placed in a stream of gasoline flowing at 0.5 m/s. The axis of the cylinder is normal to the direction of flow. It is given that the the temperature of gasoline is 20°C.

(i) Calculate the drag acting on the cylinder.

(ii) Calculate the drag if the cylinder is tilted 45° normal to the direction of the flow.

[10 marks]

6. (a). Broad crested weirs are robust hydraulic structures used to measure discharges in open channels. By applying Bernoulli and Froude equation, determine the expression for flow for a broad-crested weir with very low flow. The coefficient of discharge for broad crested weir is given as 0.65.

[10 marks]

(b). A tank filled with water is connected to a multifluid manometer as shown in **Figure 9**. The tank is pressurised by air and is located at an altitude of 1400 m with atmospheric pressure of 83.2kPa. Determine the air pressure in the tank if h_1= 0.15 m, h_2= 0.27 m, and h_3= 0.43 m. It is given that the temperature of kerosene, mercury and water is 20°C, respectively.

[10 marks]

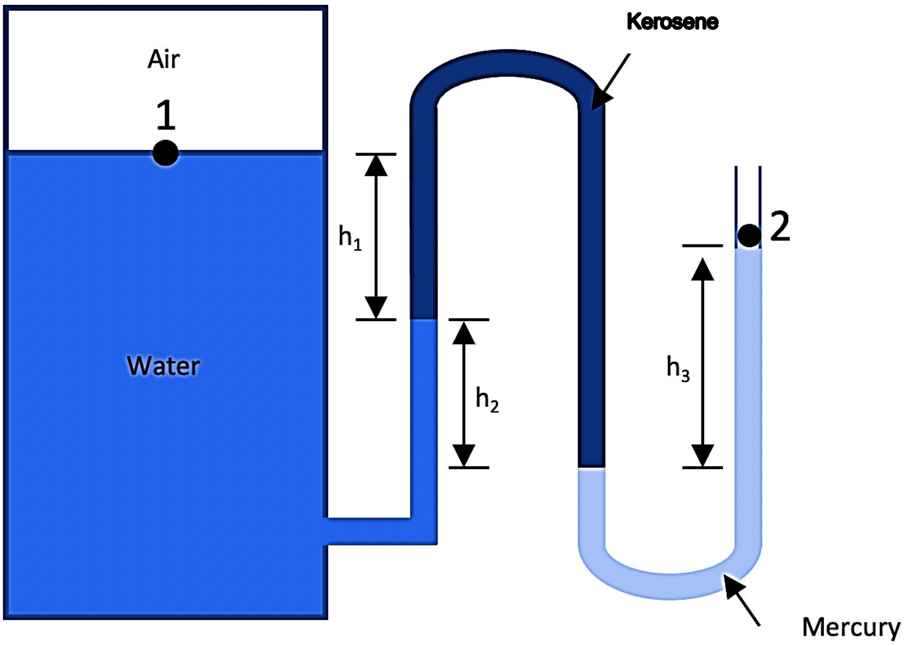


Figure 9

APPENDIX

Table 1 – Properties of Water

TABLE A.1 SI units [101 kPa (abs)]

Temperature (°C)	Specific Weight γ (kN/m^3)	Density ρ (kg/m^3)	Dynamic Viscosity η (Pa·s)	Kinematic Viscosity ν (m^2/s)
0	9.81	1000	1.75×10^{-3}	1.75×10^{-6}
5	9.81	1000	1.52×10^{-3}	1.52×10^{-6}
10	9.81	1000	1.30×10^{-3}	1.30×10^{-6}
15	9.81	1000	1.15×10^{-3}	1.15×10^{-6}
20	9.79	998	1.02×10^{-3}	1.02×10^{-6}
25	9.78	997	8.91×10^{-4}	8.94×10^{-7}
30	9.77	996	8.00×10^{-4}	8.03×10^{-7}
35	9.75	994	7.18×10^{-4}	7.22×10^{-7}
40	9.73	992	6.51×10^{-4}	6.56×10^{-7}
45	9.71	990	5.94×10^{-4}	6.00×10^{-7}
50	9.69	988	5.41×10^{-4}	5.48×10^{-7}
55	9.67	986	4.98×10^{-4}	5.05×10^{-7}
60	9.65	984	4.60×10^{-4}	4.67×10^{-7}
65	9.62	981	4.31×10^{-4}	4.39×10^{-7}
70	9.59	978	4.02×10^{-4}	4.11×10^{-7}
75	9.56	975	3.73×10^{-4}	3.83×10^{-7}
80	9.53	971	3.50×10^{-4}	3.60×10^{-7}
85	9.50	968	3.30×10^{-4}	3.41×10^{-7}
90	9.47	965	3.11×10^{-4}	3.22×10^{-7}
95	9.44	962	2.92×10^{-4}	3.04×10^{-7}
100	9.40	958	2.82×10^{-4}	2.94×10^{-7}

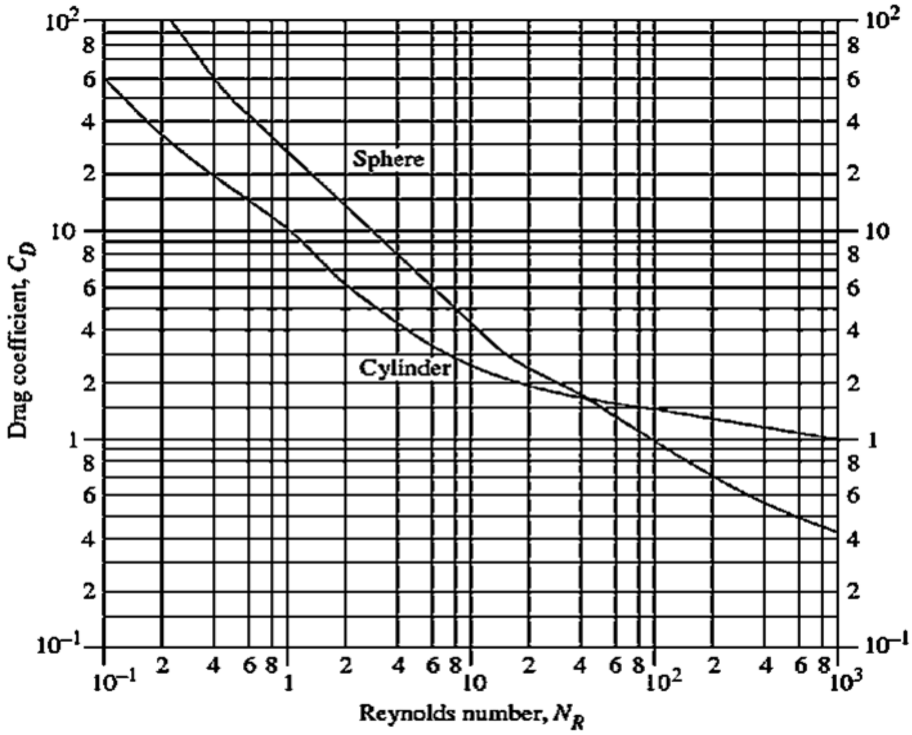
Table 2 – Physical Properties of Fluids

Physical Properties of Liquids at Standard Atmospheric Pressure 101.3 kPa, and 20°C

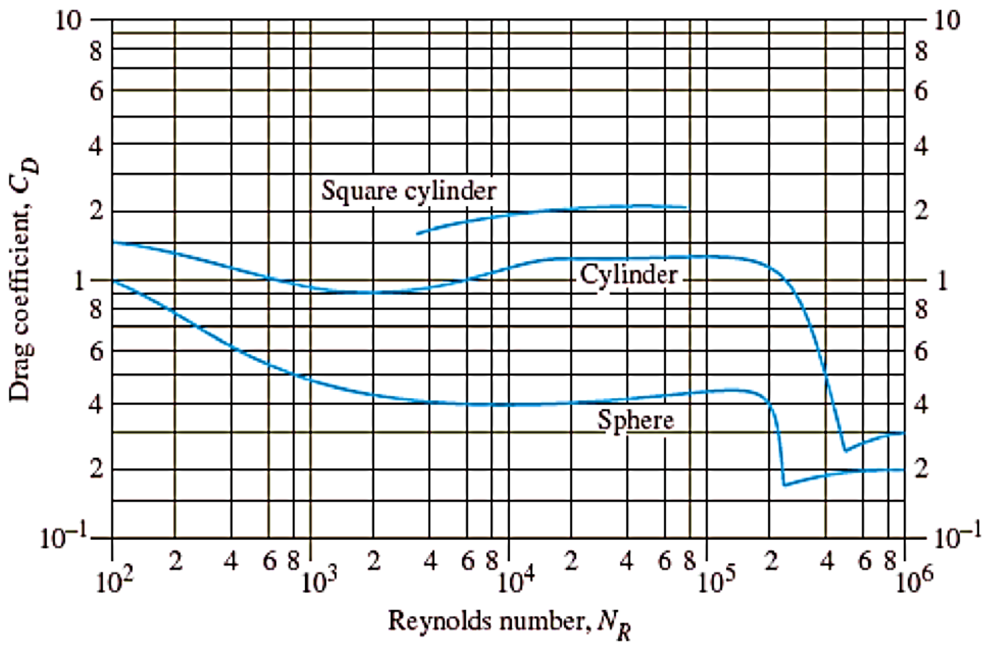
Liquid	Density ρ (kg/m^3)	Dynamic Viscosity μ (N·s/m^2)	Kinematic Viscosity ν (m^2/s)	Surface Tension σ (N/m)
Ethyl alcohol	789	$1.19(10^{-3})$	$1.51(10^{-6})$	0.0229
Gasoline	726	$0.317(10^{-3})$	$0.437(10^{-6})$	0.0221
Carbon tetrachloride	1590	$0.958(10^{-3})$	$0.603(10^{-6})$	0.0269
Kerosene	814	$1.92(10^{-3})$	$2.36(10^{-6})$	0.0293
Glycerin	1260	1.50	$1.19(10^{-3})$	0.0633
Mercury	13 550	$1.58(10^{-3})$	$0.177(10^{-6})$	0.466
Crude oil	880	$30.2(10^{-3})$	$0.0344(10^{-3})$	

Physical Properties of Gases at Standard Atmospheric Pressure 101.3 kPa

Gas	Density ρ (kg/m^3)	Dynamic Viscosity μ (N·s/m^2)	Kinematic Viscosity ν (m^2/s)	Gas Constant R (J/[kg·K])	Specific Heat Ratio $k = c_p/c_v$
Air (15°C)	1.23	$17.9(10^{-6})$	$14.6(10^{-6})$	286.9	1.40
Oxygen (20°C)	1.33	$20.4(10^{-6})$	$15.2(10^{-6})$	259.8	1.40
Nitrogen (20°C)	1.16	$17.5(10^{-6})$	$15.1(10^{-6})$	296.8	1.40
Hydrogen (20°C)	0.0835	$8.74(10^{-6})$	$106(10^{-6})$	4124	1.41
Helium (20°C)	0.169	$19.2(10^{-6})$	$114(10^{-6})$	2077	1.66
Carbon dioxide (20°C)	1.84	$14.9(10^{-6})$	$8.09(10^{-6})$	188.9	1.30
Methane (20°C) (natural gas)	0.665	$11.2(10^{-6})$	$16.8(10^{-6})$	518.3	1.31



(a) C_D vs. N_R for lower values of N_R



(b) C_D vs. N_R for higher values of N_R

Figure 1 – Drag coefficients for spheres and cylinders

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