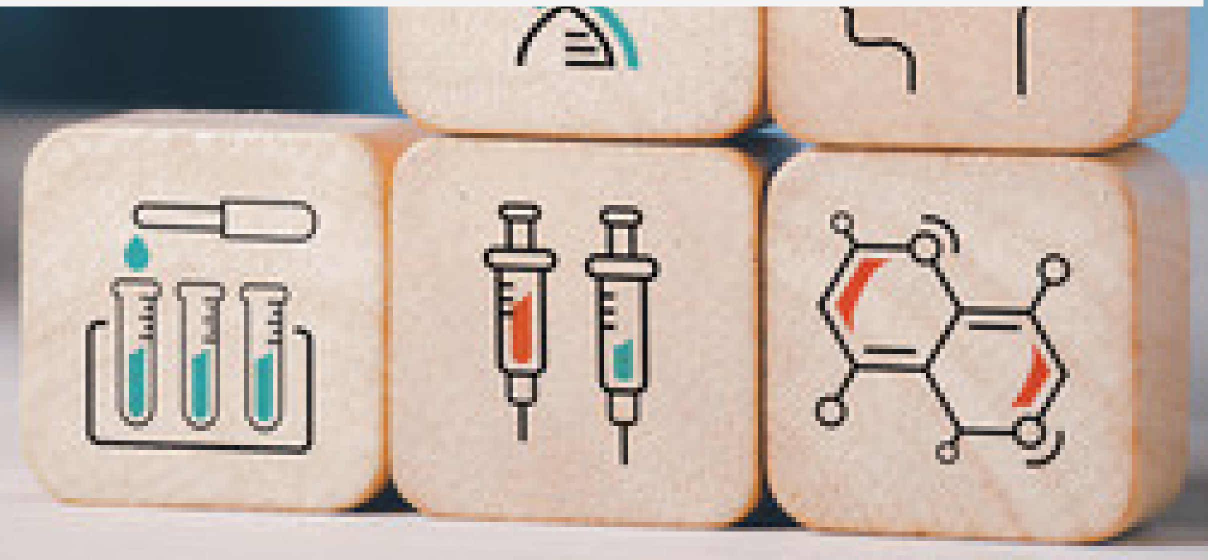
NURSE SCHEDULING

The Battle for Efficient Healthcare



OUR TEAM

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PROBLEM STATEMENT

- The scheduling of nurses is currently one of the most challenging issues hospitals face in managing their staff on a day-to-day basis.

- The influx of patients at the blood center varies greatly at different times.

PROBLEM STATEMENT

- **Due to the high demand for the service, the peak capacity of the blood center is inadequate, resulting in lengthy queues.**
- **During periods of low demand, there is excess capacity in the service which results in the inefficient utilization of human resources.**

Real-World Examples of Nurse Scheduling Problem

- Healthcare organizations globally face the challenge of the nurse scheduling problem.
- Which has significant consequences, such as hospitals in the United States spending $5 billion yearly on nurse overtime due to insufficient staffing.
- In Canada, nurse scheduling has been identified as a leading cause of burnout and turnover among healthcare professionals.

OUR SOLUTION

- **Our approach to addressing the burden on full-time nurses during high-volume periods and avoiding inefficiencies in resource utilization involves hiring part-time nurses and adjusting the number of nurses scheduled during times of low demand.**

- **To tackle the problem, we have tried to use the Queuing Theory along with Mixed Integer Programming to develop an efficient solution for the same.**
- **The Queuing Model we have used is M/M/C model denoting Markovian distribution of lead and service time and c is the number of nurses that must be present in a given shift on a particular day and the MIP helps in the assignment of these nurses in the duty roster.**

CPLEX CODE

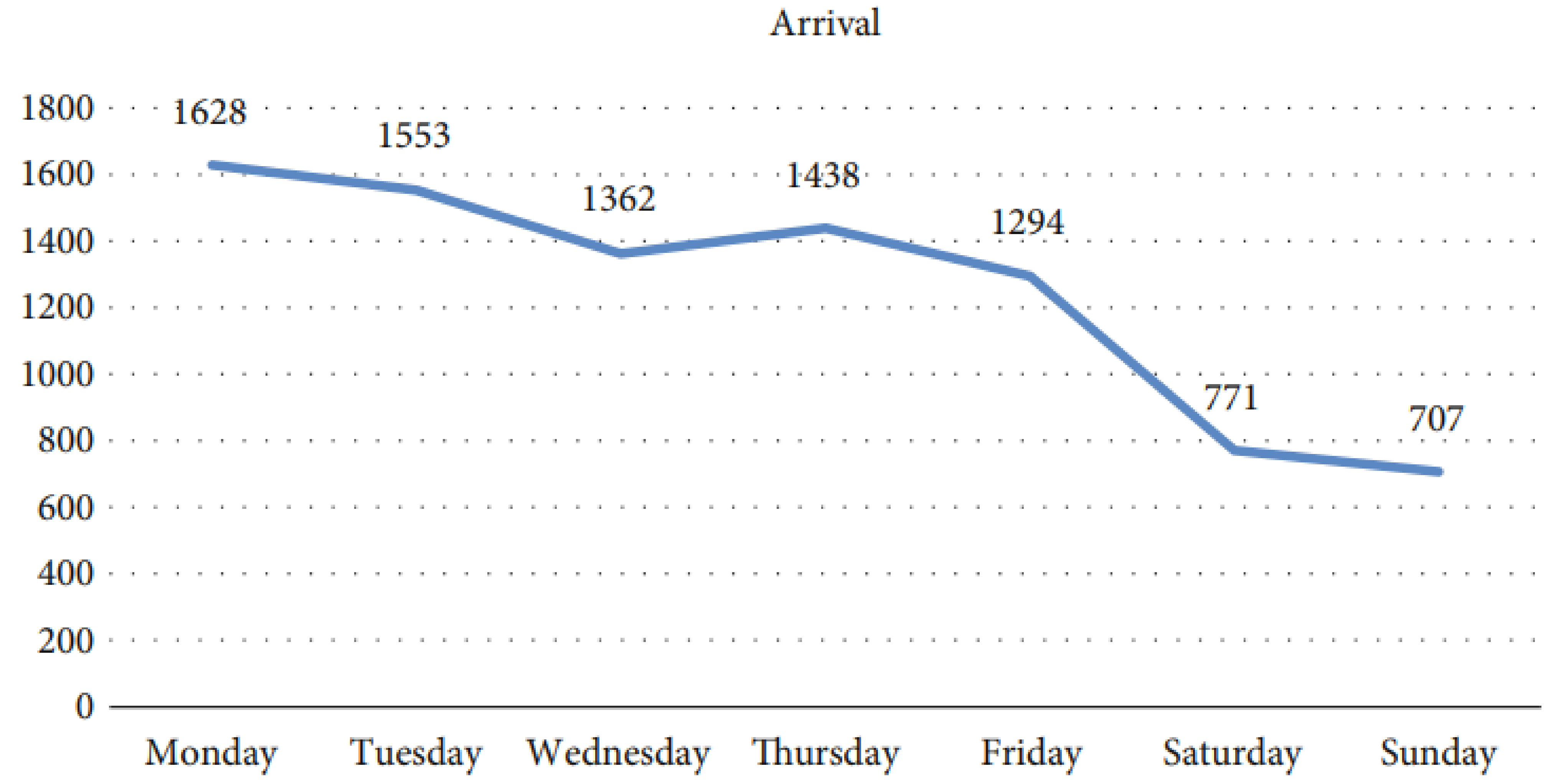
```
//Objective Function
//Minimizing the number of days worked by full-time nurses given that the total number of hours worked by all nurses is minimized
dexpr int ans = (sum(i in perm_nurse, d in day) z[i][d]) + (sum(i in perm_nurse, d in day, t in period) x[i][d][t]) +
(sum(j in part_nurse, d in day, t in period) y[j][d][t]);
//Constraints-->

subject to{
  //Number of part-time + permanent nurse on a given shift should be greater than the required number
  constraint1:
  forall(d in day, t in period) (sum(i in perm_nurse) x[i][d][t]) + (sum(j in part_nurse) y[j][d][t]) >= c[d][t];

  //Ensuring there is no considerable difference in the working hours of two permanent nurse in the planning period
  constraint2:
  forall(i, j in perm_nurse : i != j){
    abs((sum(d in day, t in period) x[i][d][t]) - (sum(d in day, t in period) x[j][d][t])) <= n;
  }

  //Limiting  the maximum number of consecutive hours for which the nurses work per day

  //For permanent nurses
  constraint3:
  forall(i in perm_nurse, d in day, k in 1..days-nt) sum(t in k..k+nt) x[i][d][t] <= nt;

  //For part time nurses
  constraint4:
  forall(i in part_nurse, d in day, k in 1..days-nt) sum(t in k..k+nt) y[i][d][t] <= nt;

  //Enforcing the the maximum and minimum number of consecutive working days for each full-time nurse
  constraint5:
  forall(i in perm_nurse) sum(d in day) z[i][d] <= ndmax;
  forall(i in perm_nurse) sum(d in day) z[i][d] >= ndmin;
```

DATA

Days	7 a.m.–10 a.m.	10 a.m.–1 a.m.	1 p.m.–5 p.m.
Monday, Tuesday	5.23	2.16	0.79
Wednesday, Thursday, Friday	4.56	1.61	0.67
Saturday, Sunday	2.45	0.89	0.42

Patient Arrival Rate (people/min) for different time shifts and days

Number of Patients arriving on different days



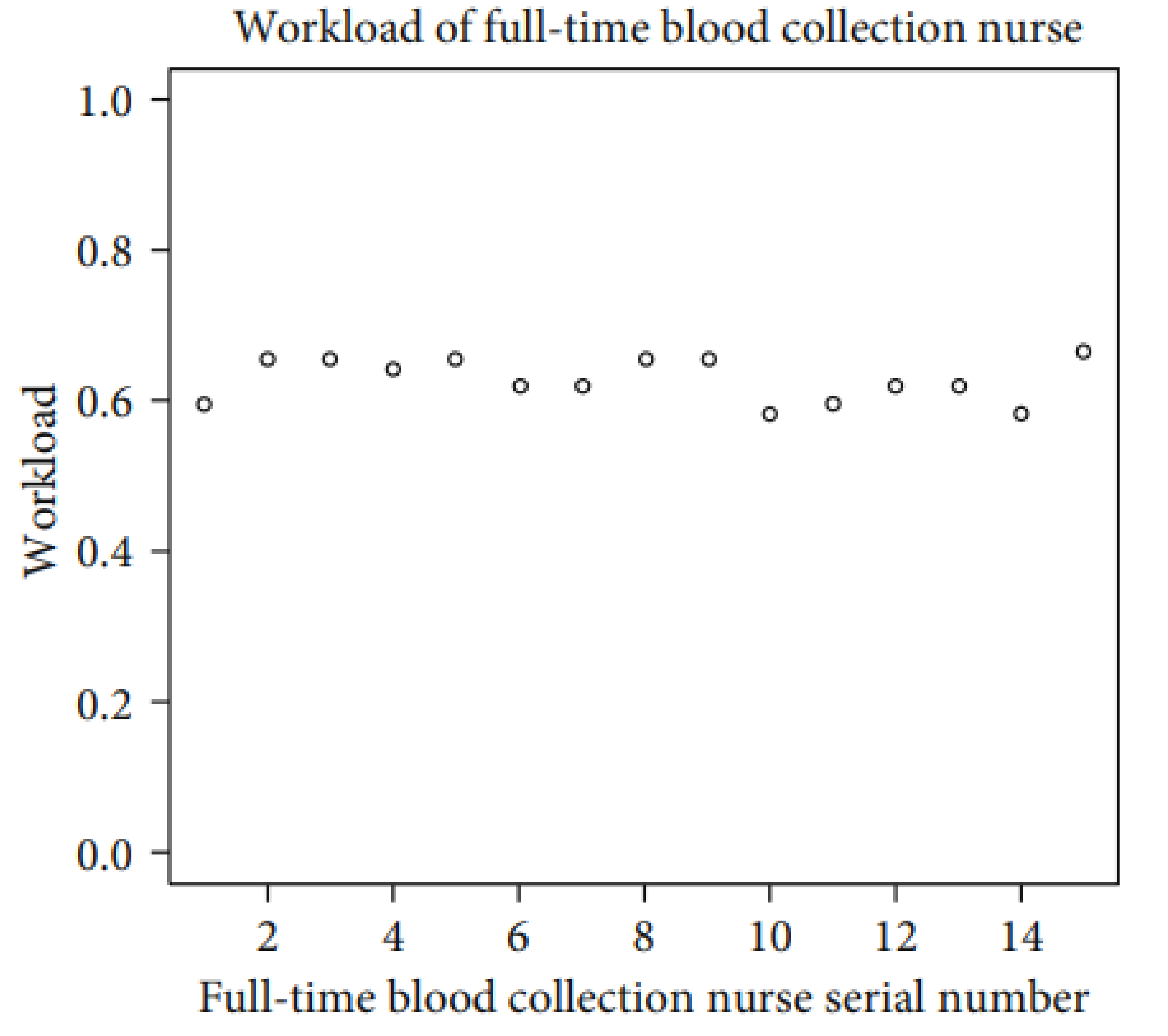
RESULTS

Nurse	1	2	3	4	5	6	7	8	9	10
Days worked	1	2	2	1	1	1	2	1	2	1
	2	3	3	2	2	2	3	2	3	3
	5	4	4	4	4	3	5	3	4	4
	6	5	5	5	5	4	6	4	5	5

Days that each blood collection nurse works.

Date	λ	Period	c.min	W_q	L_q	P_q	W	L	P	$c\_$
Monday	5.23	1	9	1.33	6.98	0	2.9	15.15	0	8.17
	2.16	2	4	1.69	3.66	0	3.26	7.03	0	3.38
	0.79	3	2	0.96	0.76	0	2.52	1.99	0	1.23
Wednesday	4.56	1	8	1.21	5.51	0	2.77	12.63	0	7.12
	1.61	2	3	2.29	3.69	0.01	3.86	6.21	0.01	2.52
	0.67	3	2	0.59	0.4	0	2.15	1.44	0	1.05
Saturday	2.45	1	5	0.65	1.6	0	2.22	5.43	0	3.83
	0.89	2	2	1.46	1.3	0	3.02	2.69	0	1.39
	0.42	3	1	2.98	1.25	0.02	4.55	1.91	0.04	0.66

Predicted Minimum Number of open blood collection windows



Real World Applicaton

- As healthcare continues to evolve, so too will the nurse scheduling problem. New technologies, such as artificial intelligence and machine learning, may offer new solutions to this complex task. For example, predictive analytics could be used to forecast patient demand and adjust nurse schedules accordingly.

- In addition, there is growing interest in patient-centered scheduling, which involves aligning nurse schedules with patient needs and preferences.
- This approach could help to improve patient satisfaction and outcomes, while also enhancing nurse engagement and retention.

CONCLUSION

- Queuing and nurse scheduling models were proposed herein to solve the issue of rostering nurses.
- First, the queuing model determined the minimum labor demand during each period of each day, which served as the primary input for the scheduling model.
- This model was then used to determine the nurses’ shift schedules and organize the full-time nurses’ shifts to ensure fairness.

- Results of numerical studies conducted using data from a large hospital in China show a significant improvement in patient waiting time performance metrics over the hospital’s current practice.
- The proposed model could generate reasonable rosters to handle relatively large fluctuations in patient numbers.
- In summary, we proposed methods for making decisions about staff numbers and scheduling that can improve work efficiency.

REFERENCES

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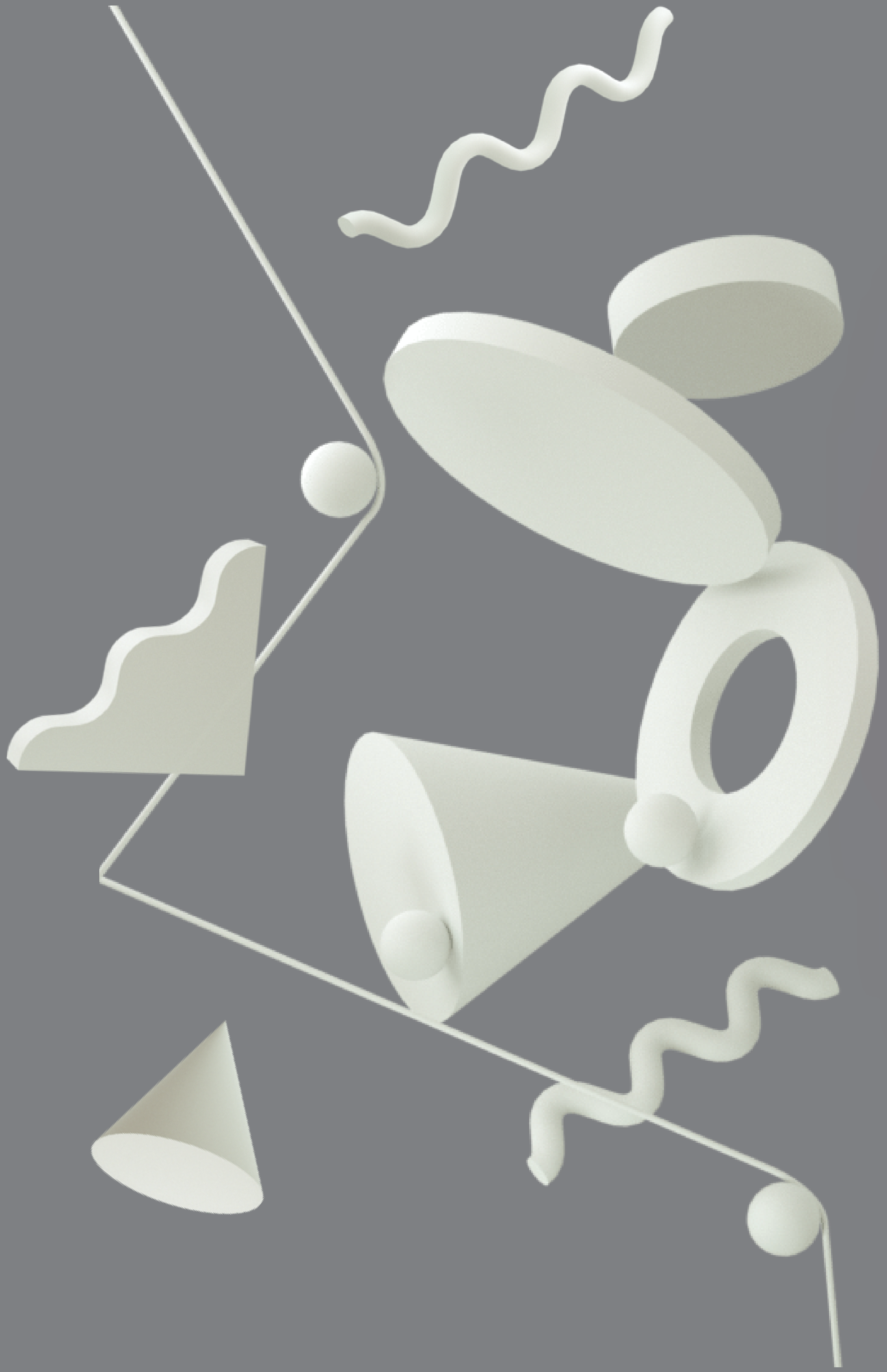

THANK YOU