## ***City University London***

*School of Engineering and Mathematical Sciences*

*Engineering Drawing and Design, ME1110*

Exercise code: DP-1
Exercise type: Group Design Project
Exercise title: Detailed Design – Redesign of the helicopter

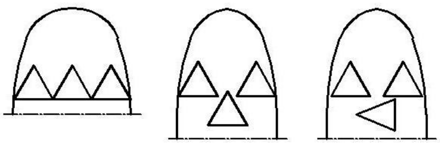
### Exercise Assignment:

### Task (Objective):

Produce an outline design which converts the Robinson R-22, 2-seater helicopter to a 3-seater and a detailed design of the tail rotor shaft and bearings

### HOW to calculate:

1. **Power, weight and dimensions:**
   Use data from the Table and Figure. First find the new AUW weight $W_1^n$ for N=3 assuming $R_1 = \{W_1/N\}$ is constant. Then assume ratios $R_2 = \{W_2/P\}$, $R_3 = \{W_1/\pi R^2\}$, $R_4 = \{W_2/W_1\}$ and $\{R/r\}$ constant and estimate the new values of $P^n$, $R^n$, $r^n$ and $W_2^n$.
2. **Engine weight:**
   The existing engine is de-rated from 119 kW to 98 kW at 2652 rpm. Therefore the weight of the existing engine corresponds to that at 119kW. The engine weight is proportional to the power. Estimate the engine weight for the new power.
3. **Engine centre of mass position:**
   On the standard R22, the engine centre of mass (CM) is 0.5 m aft of the datum (line indicated in Figure 1). The minimum pilot, passenger and baggage load $W_{2min}$= 97.5 kg sitting 0.5 m forward of the datum. The maximum load, $W_{2max}$=195 kg (1 pilot +1 passenger), is also 0.5 m forward of datum (since they sit next to each other). Therefore, the mean load is $W_{2mid}$=146 kg, which is also 0.5 m forward of the datum. The mean load balances the engine moment. If the helicopter is maximally loaded it will be 'nose heavy'. If there is only a pilot in the helicopter it will be 'tail heavy'.
   On re-design, assume the fuselage dimension changes to be self-balancing. Estimate the new engine centre of mass position such that it balances the new mean load (min=1 pilot, max=1 pilot + 2 passengers),
4. **Seat configuration:**
   Possible seat configurations are shown in the figure. You are invited to think about other possibilities and consider them together with these three.



### HOW to make a report:

Conduct all phases of the design process (1 – 10) and refer to each of these in the report. The report must contain:

- General view of the redesigned 3-seater helicopter showing the most important dimensions. That includes a plan view which shows the seat configuration and the engine position.
- Detailed drawing(s) of the tail blade with the special attention to the connection with the shaft.
- All calculations for the redesigned parameters and for the moment balance.
- Report must consist of a title page, index, several pages of main project, conclusion and bibliography. It should be conveniently bounded. Include in the report: Results of the search, Constraints, Criteria, Alternative solutions, a decision matrix with a written submission listing the reasons for choosing the final seat configuration. A bill of material for the new helicopter. The estimated price.

### *Exercise tips:*

***This is a three-week group exercise.*** *It is worth 20 marks. The report should be written on as many A3 drawing papers as necessary and should have front page, index, main body, conclusion and bibliography. The report should be folded or stapled. All drawings may be made in AutoCAD.* ***<u>Hand in finished report to U/G Mechanical & Aeronautical office, C108, in week 8</u>*** (check the deadline on the web).

*Fill in all relevant data in the title block.*


*Figure 1 Robinson R22 ‘Beta’*

| **Helicopter model** | | | **Robinson R22 ‘Beta’** | **Schweizer 300C** | **Enstrom 280FX** | **Rogerson Hiller 12E** |
|---|---|---|---|---|---|---|
| **Engine** | | | Lycoming 0-320 | Lycoming H10-360 | Lycoming H10-360 | Lycoming V0-540 |
| Parameters | Name | Unit | | | | |
| No of seats | N | | 2 | 3 | 3 | 3 |
| All-up-weight (AUW) | $W_1$ | kg | 621 | 930 | 1179 | 1406 |
| Engine weight (incl. in $W_1$) | $W_e$ | kg | 146 | | - | - |
| Fuel weight | $W_f$ | kg | 52 | | | |
| Pilot, passengers, baggage | $W_2$ | kg | 195 | 349 | 277 | 483 |
| Engine power | P | kW | 98 | 142 | 168 | 227 |
| Main rotor diameter | 2R | m | 7.67 | 8.13 | 9.75 | 10.67 |
| Number of blades | $n_b$ | | 2 | 3 | 3 | 2 |
| Tail rotor diameter | 2r | m | 1.07 | 1.14 | 1.36 | 1.49 |
| | | | | | | |
| Max. Speed | $v_{max}$ | km/h | 191 | 176 | 189 | 154 |
| Price | Cost | $ | 167,000 | 266,400 | 359,250 | 483,800 |
| Price per unit AUW {Cost/$W_1$} | | $/kg | 283 | 286 | 304 | 344 |
| | | | | | | |
| Ratios: | | | | | | |
| $W_1/N$ | $R_1$ | kg | 311 | 310 | 393 | 467 |
| $W_2/P$ | $R_2$ | kg/kW | 6.34 | 6.55 | 7.02 | 6.19 |
| $W_1/\pi R^2$ | $R_3$ | kg/m$^2$ | 13.44 | 17.91 | 15.79 | 15.72 |
| $W_2/W_1$ | $R_4$ | | 0.314 | 0.375 | 0.235 | 0.344 |
| | | | | | | |