KEY

NAME

ONID

PH 202 MID TERM #1

Instructions:

Do not open the test until prompted to do so.

Read all the questions thoroughly and ask if you have any questions.

You have 40 minutes to complete the test.

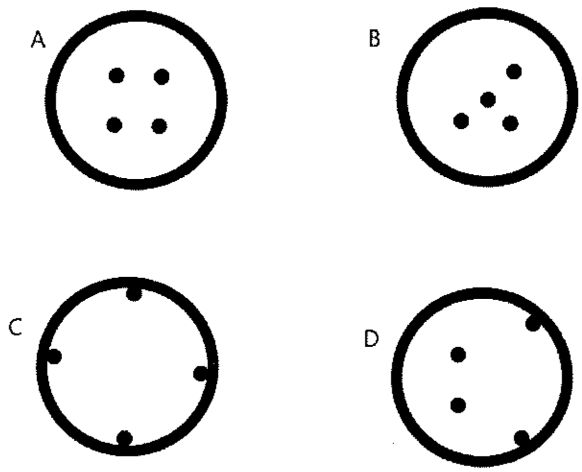
You may use:

- Up to 10 pages of notes of any kind
- A non-communicating calculator
- Your brain

Points break-down for each problem:

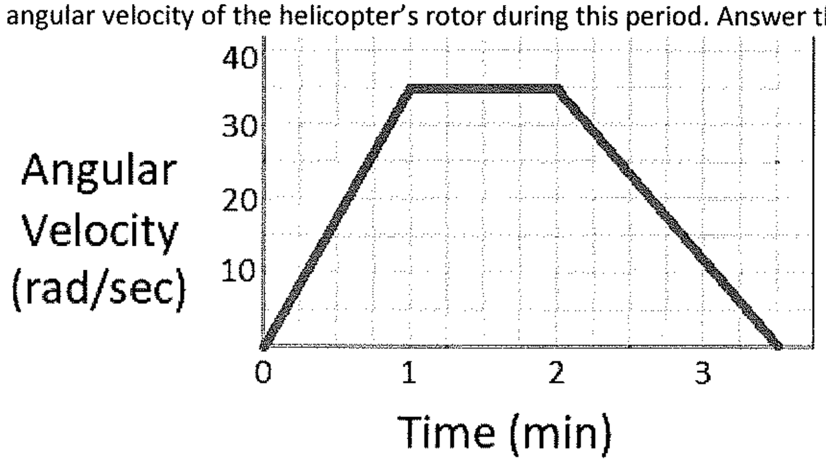
Question #1	4 points
Question #2	6 points
Question #3	20 points
Question #4	20 points (plus 2 bonus points)
Total	50 points (plus an additional 2 bonus points)

1) Four identical children (shown as the black dots) arrange themselves on a spinning playground merry-go round (the black circle) in several arrangements. Assuming each of these arrangements has an angular momentum of 560 kg*m^2/s, rank the following in terms of angular velocity from slowest to fastest.



C < D < A < B

2) A helicopter starts its engines and the rotor accelerates up to a full speed of 35 radians per second. The helicopter remains running on the ground for a minute, and then shuts off the engines. Friction causes the rotor to slow down until it stops. The graph below shows the angular velocity of the helicopter's rotor during this period. Answer the below questions:



- (3 pts) Between 1 min and two minutes the helicopter is in:
    a) Rotational static equilibrium and translational dynamic equilibrium
    b) Translational static equilibrium and rotational dynamic equilibrium
    c) Rotational dynamic equilibrium and translational dynamics
    d) Translational static equilibrium and rotational dynamics
- (3 pts) The total angular displacement of the rotor over the entire period is:
    a) 78.75 radians
    b) 4725 radians
    c) 122.5 radians
    d) 35 radians

3) A bobsled moving at 40 meters per second enters a portion of circular track at point A with a radius of 100 meters. For the first 3 seconds, the brake is applied, slowing the bobsled at a constant rate to 35 meters per second at point B. At point B, the brake is released, and the sled constantly accelerates back to 40 meters per second over the next 5 seconds, reaching that speed at point C.

(6 pts) What is the angular acceleration during the first 3 seconds of the turn (from A to B)?

$V_i = 40 \, m/s \quad r = 100m$

$\omega_i = \frac{V_i}{r} = \frac{40 m/s}{100m} = 0.4 \frac{rad}{sec}$

$V_f = 35 \, m/s$

$\omega_f = \frac{V_f}{r} = \frac{35 m/s}{100m} = 0.35 \frac{rad}{sec}$

$\omega_f = \omega_i + \alpha \Delta t$

$\Rightarrow \alpha = \frac{\omega_f - \omega_i}{\Delta t}$

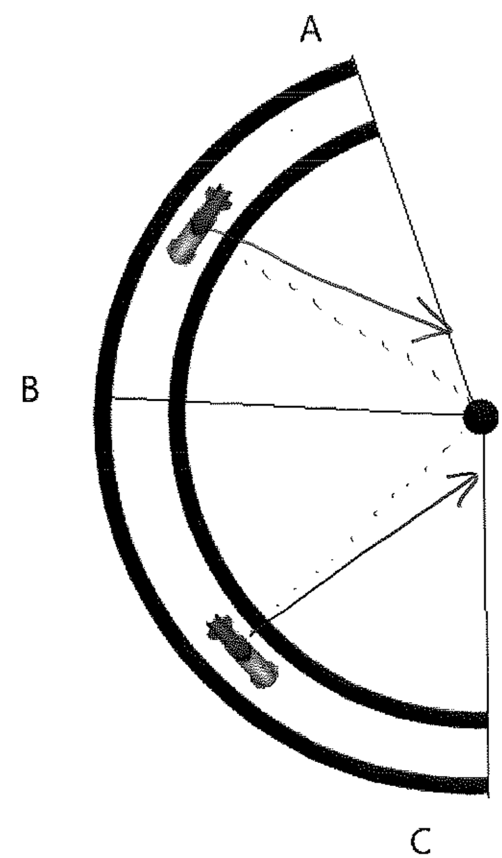
$\alpha = \frac{0.35 \frac{rad}{sec} - 0.4 \frac{rad}{sec}}{3 sec}$

$\alpha = -0.017 \, rad/sec^2$

(6 pts) What is the radial acceleration at 3 seconds after entering the turn (point B)?

$a_r = \frac{V^2}{r} = \frac{(35 m/s)^2}{100m}$

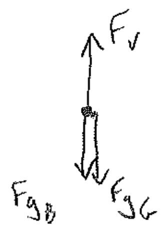
$a_r = 12.25 \, m/s^2$



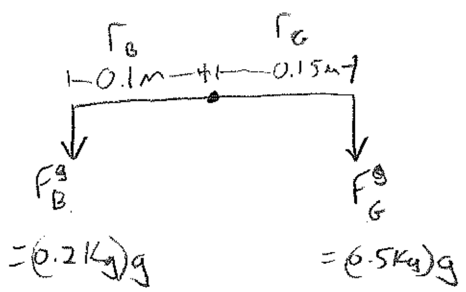
(8 pts) On the diagram, draw an arrow on each bobsled representing the direction of the overall acceleration of the bobsled.

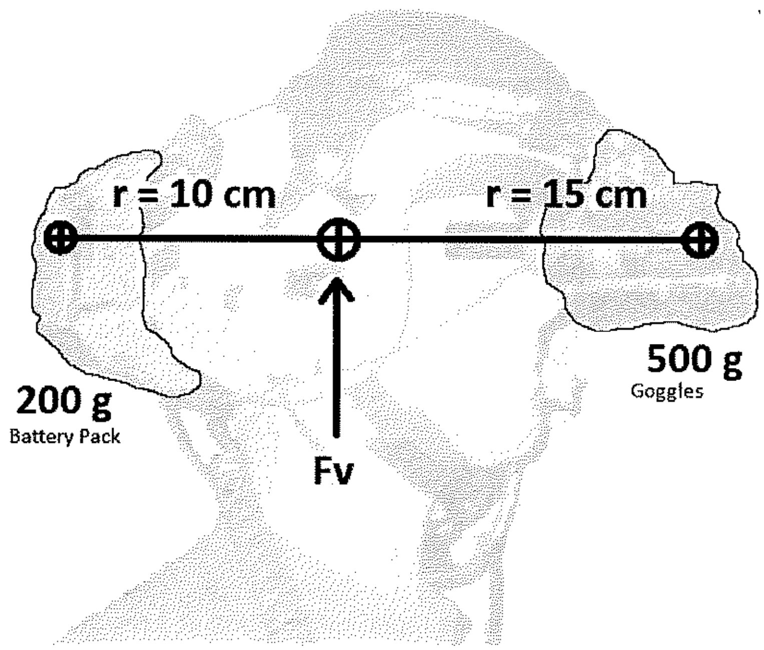
4) A pilot flying at night is wearing a set of night vision goggles on their helmet. The goggles have a mass of 500g located 15 cm in front of the pivot point. The 200g battery pack is attached to the back of the helmet, 10 cm behind the pivot point. Overall the weight of the system is supported by the head and neck pushing up on the center of mass for the helmet/goggles system. Assume the reference axis is about the center of mass.

(3 pts) Draw a FBD for the system.



(3 pts) Draw an eFBD for the system.





(6 pts) What is the resulting torque that the night vision goggles and battery pack place on the head?

$$\Sigma \tau = F^g_B r_B - F^g_G r_G = (0.2kg)(9.8\,m/s^2)(0.1m)\sin(90^\circ) - (0.5kg)(9.8\,m/s^2)(0.15m)\sin(90^\circ)$$

$$\boxed{\Sigma \tau = -0.54\ Nm}$$

(8 pts) If you were to add a mass to the system, either on the battery pack or the goggles, how much mass would you need to add to balance out the torque? Where would you add the mass?

NEED $\Sigma \tau = 0$ ⇒ MUST CREATE $\tau = 0.54\,Nm$ ⇒ ADD TO BATTERY PACK!!

$$\tau = |\vec{F}||\vec{r}|\sin\phi = 0.54\,Nm$$

$\phi = 90^\circ$ $r = 10cm = 0.1m$ $F = \dfrac{0.54\,Nm}{(0.1m)(\sin 90^\circ)} = 5.4N$

$F = mg$ $\boxed{m = 0.55\,Kg}$

Bonus (2 pts): After adding weight, what is the force felt on the neck by the goggles and battery pack?

$$\Sigma F_y = F_v - F^g_B - F^g_G - F^g_W = 0$$

$$F_v = (0.2Kg)(9.8\,m/s^2) + (0.5Kg)(9.8\,m/s^2) + (0.55Kg)(9.8\,m/s^2) = \boxed{12.25\,N}$$