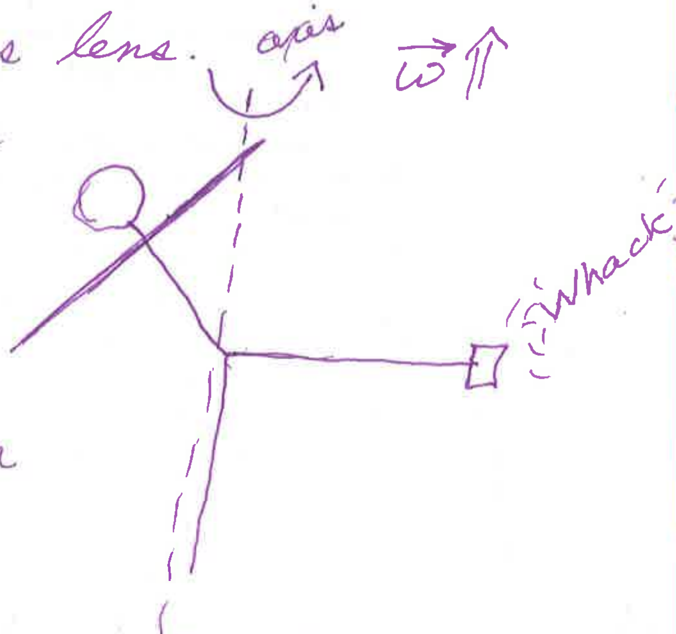
2) In doing a roundhouse kick (where the kicker spins about a vertical axis), explain with proper physics reasoning how the kicker should move her arms, and why this works. at the moment she kicks

I can use either an $\vec{L}$ lens or a rotational dynamics lens.



In both cases, we recognize that we are already spinning about a vertical axis (upward in this drawing), but we want the kicking leg to spin as fast as possible! in both cases, we separate the body into an upper half + a lower half and recognize that if only 1 foot is on the ground, $r \sim 0$, $\tau \sim 0$, so $\vec{L}$ is conserved.

<u>Angular Momentum</u> $\Rightarrow \vec{L}_{Body} = \vec{L}_{Top} + \vec{L}_{Bottom}$

so $\Delta\vec{L}_{Body} = 0$, because $\tau = 0$

so $\Delta\vec{L}_{Top} = -\Delta\vec{L}_{Bottom}$. so, we spin the top half in the downward direction + impart upward $\Delta\vec{L}$ to the bottom half.

<u>Rotational Dynamics</u> $\vec{\tau} = I\vec{\alpha}$, a <u>Torque</u> is a turning force between 2 bodies, affecting each in the opposite direction: "For every torque, there's an = + opposite torque"... So there is a torque between the upper and lower body.

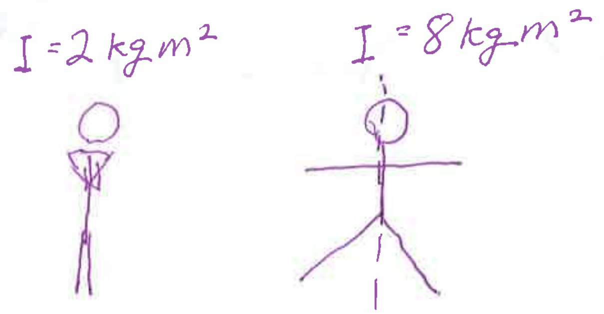
Big Exam #5 Name________________________ *Graded on **Communication** of Physics*

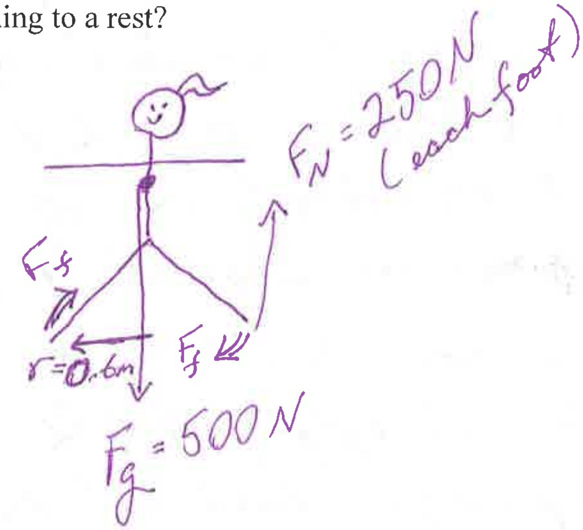
1) A 50 kg dancer, standing with her feet together (10 cm apart) and her arms in has a moment of inertia of about 2.0 kg*m^2 about the vertical axis, and that when she has her feet 1.2 meters apart and her arms stretched out has a moment of inertia of 8 kg*m^2. She is standing on a surface that provides a coefficient of friction of 0.4. She spreads her feet apart and spins herself as hard as possible (without slipping) with outstretched arms for 0.5 seconds, and then pulls her arms and feet in close and spins with her feet slipping on the floor.

a) What torque does she apply to her body as she tries to spin herself?

b) What is her maximum angular velocity as she spins, sliding on the floor with her arms pulled in?

c) How long does she spin on the floor before coming to a rest?





Dynamics because $\vec{\tau}, I, \vec{L}$

a) $\vec{\tau} = \vec{r} \times \vec{F} = rF_\perp$, $\vec{F}_f$ is $\perp$ $\vec{r}$

$F_f = F_N \cdot \mu$ $\Sigma F_y = 0$, so $2F_N = F_g$ $F_N = 250N$

2 feet on ground

$F_f = 250N \cdot 0.4 = 100N$

$\vec{\tau} = rF_f = 0.6m \cdot 100N = 60Nm$, but we have 2 feet, pushing in opposite directions applying $\vec{\tau}$ in same direction. $\Sigma \vec{\tau} = 120Nm$ (downward in my picture)

b) I use angular momentum because $\vec{L} = \vec{L}_0 + \Delta\vec{L}$

also, now she pulls her arms + feet in, so we know $I = 2 kgm^2$

$\vec{L} = 0 + \vec{\tau} \cdot \Delta t$

$\vec{L} = 120Nm \cdot 0.5s$

$\vec{L}_f = 60 \frac{kgm^2}{s}$

$\vec{L}_f = I_f \vec{\omega}_f$ $\omega = \frac{L_f}{I_f} = \frac{60 \frac{kgm^2}{s}}{2 kgm^2} = 30/s$ ← ~ 5 rev/s!

c) $\Delta\vec{L} = \vec{\tau} \cdot \Delta t$ $\tau_{apart} = 12\,\tau_{together}$ because 1.2m = (12)(10cm)

because $\Delta\vec{L}_{speeding\ up} = -\Delta\vec{L}_{slowing\ down}$ $\Delta t = 12(0.5s) = 6s$