2019 AP Physics C Mechanics Free Response, Version 1

1a.i. Increase

1a.ii. The acceleration is positive because the slope of the velocity versus time graph is positive. The acceleration is decreasing in magnitude because the slope is decreasing in magnitude.

1.a.iii. The slope at 0.20s is approximately 2.4m/s^2.

1b.i. If v = 1.18(1 – e^{-5t}), then y = $\int 1.18(1 - e^{-5t})dt$ = 1.18t – 0.236(1 – e^{-5t}).

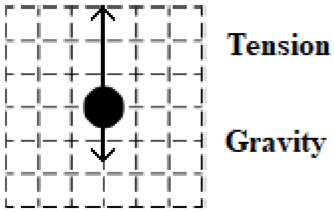
1b.ii. a = $\frac{dv}{dt}$ = 5.9e^{-5t} and ΣF = ma = 0.0708e^{-5t}.

1c.i. The speed is approximately 1.18m/s as this is the limit of the speed function as t approaches infinity.

1c.ii. The net force is zero when the acceleration is zero, so the drag force is equal in magnitude to the force of gravity on a 12g object, approximately 0.12N.

2a. $3MgL = \frac{1}{2}(3M)v^2$ so $v = \sqrt{2gL}$

2b.



2c.

$\Sigma F = ma$

$-mg + F_T = m \cdot \frac{v^2}{R}$ so $F_T = m(g + \frac{v^2}{R}) = (3M)(g + 2g) = 9Mg$

2d. $t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{3}{10}} = 0.55s$

2e. $v = \frac{x}{t} = \frac{3m}{0.55s} = 5.5m/s$

2f. By conservation of momentum, $(3M)(\sqrt{15}) + 0 = (3M)(v) + (M)(5.5)$, so $v = 2.04m/s$

2g. By conservation of energy, $\frac{1}{2}mv^2 = mgh$ and $h = L(1 - \cos\theta)$

$v^2 = 2gL(1 - \cos\theta)$ so $2.04^2 = 15(1 - \cos\theta)$ and $\theta = 43.7^o$.

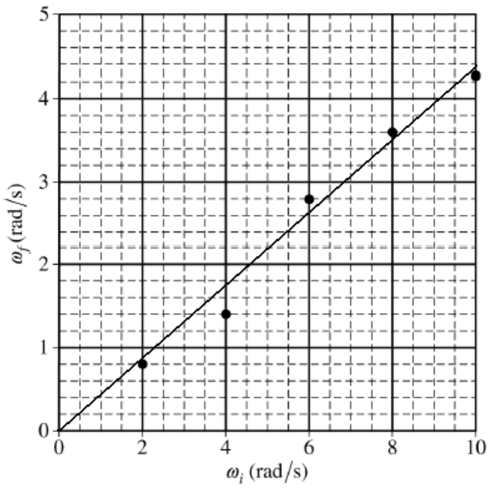
3a. $\tau = I \cdot \alpha$ so $D \cdot F = I_P \cdot \frac{\omega_P}{\Delta t}$ and $\omega_P = \frac{DF\Delta t}{I_P}$

3b. $K = \frac{1}{2} I_P \cdot \omega_P^2 = \frac{D^2 F^2 \Delta t^2}{2 \cdot I_P}$

3c. $\omega_W \cdot r = \omega_P \cdot D$ so $\omega_W = \omega_P \cdot \frac{D}{r}$

3d. $L_i = L_f$ so $I_P \cdot \omega_P = (2I_P)\omega_f$ and $\omega_f = \frac{\omega_P}{2}$

3e.i.



3e.ii. $L_i = L_f$ so $I_P \cdot \omega_P = (I_P + I_U)\omega_f$ and slope $= \frac{\omega_f}{\omega_i} = \frac{I_P}{I_P + I_U}$

$0.44 = \frac{3.1}{3.1 + I_U}$ so $I_U = 3.95 \text{kg} \cdot \text{m}^2$

3f. The final kinetic energy is less than the initial kinetic energy because total energy is conserved and thermal energy is generated by kinetic friction as the system reaches a common angular velocity.

3g. Greater than. If the object is dropped onto the platform so that its center is not aligned with the axis, by the parallel-axis theorem, the rotational inertia will be greater than it is through the center of mass.
$I = I_{cm} + Mh^2$ and if h is anything but zero, the rotational inertia is greater than I_{cm}.