Task 1

Research object:

Bullet with projectile motion

constraints:

mass $= 13.6g$

$v_0 = 870\ ms^{-1}$

$L = 1500\ m$

H

air friction coefficient $k = 1.3 \times 10^{-5}$

Solution:

Basic projectile motion

- without friction

$v_{x0} = v\cos\alpha$ $\quad$ $v_x = v\cos\alpha$

$v_{y0} = v\sin\alpha$ $\quad$ $v_y = v\sin\alpha - gt$

$a_x = 0$

$a_y = -g$

$$H = \frac{v^2\sin^2\alpha}{2g}$$

$$R = L = \frac{v^2\sin 2\alpha}{2g}$$

we can find α from L equation

$$\alpha = \frac{\arcsin(Lg/v^2)}{2} = 0.556$$

we can find the cargo ship maximum height from L equation

$$H_{max} = 10771.825354\ m$$

- without air drag

$F_c = -kv^2$

$v_{x_0} = v\cos\alpha$ $\quad$ $v_x = v\cos\alpha - \frac{F_c t}{m} = v\cos\alpha - \frac{kv_x^2 \cdot t}{m}$

$v_{y_0} = v\sin\alpha$ $\quad$ $v_y = v\sin\alpha - \frac{gt}{m} - \frac{kv_y^2}{m}$

$a_y = \frac{-g}{m} - \frac{kv_y^2}{m}$ $\quad$ $a_x = \frac{kv_x^2}{m}$

we need to use numerical integration to find the velocity then integrate in order to find the position in x-axis Then we can substitute initial conditions to get α

By numerical integration for the differential equation :

$$\frac{dv_x}{dt} = -\frac{k v_x^2}{m}$$

Task 2

Research object:

Particle M - translatory motion in tube ~~rotational motion~~ (planar motion)

Object A - rotational motion

Constraints:

$m = 0.02$ kg

$\omega = \pi$ rad.s^{-1}

$r = 0.5$ m

initial conditions:

$t_0 = 0$

$x_0 = 0$

$\dot{x}_0 = 0.4$ m.s^{-1}

Force analysis:

G (particle weight)

N

Solution: when the particle is at the origin (starting point)

$$m\ddot{x} = \sum_i F_i + F_e$$

$$F_e = m\omega^2 x$$

$$m\ddot{x} = mg\sin\omega t + m\omega^2 x$$

$$\ddot{x} = g\sin\omega t + \omega^2 x$$

$$\ddot{x} - \omega^2 x = g\sin\omega t$$

$$x_1 = C_1 e^{\omega t} + C_2 e^{-\omega t}$$

$$x_2 = A\sin\omega t$$

till the time the point won't leave the channel $t = 0.3$

To find pressure:

$$N + F_c - mg\cos\omega t = 0$$

$$F_c = 2m\omega v_r \rightarrow \dot{x}$$

$$\Rightarrow N = mg\cos(\omega t) - 2m\omega v_r$$

Task 3

Research object:

System of
- 3 masses
- 2 pulleys
- strings
- Big block

Force analysis:

T_1, T_2

$R_n \quad R_y$

G_1, G_2, G_3

$N_2 \quad N_3$

$F_{r_3} \quad F_{r_2}$

Solution:

$$(M_1 + M_2 + M_3)\, a = F_{r_1} + F_{r_2} \cos(60)$$

$$N_2 = M_2 g$$

$$N_3 = M_3 g \cos(60)$$

$$F_{r_2} = \mu N_2 \qquad F_{r_3} = \mu N_3$$

we can integrate acceleration with respect to time to get velocity, then integrate to get position

another Solution: using center of mass theorem of motion

$$x_c = \frac{\Sigma m_i x_i}{\Sigma m_i} = \frac{m_1 x_{c_1} + m_2 x_{c_2} + m_3 x_{c_3} + m x_c}{\Sigma m_i}$$

$$= \frac{m_1(x_{c_1} - \Delta) + m_2(x_{c_2} + 1 - \Delta) + m_3(x_{c_3} + \frac{1}{2} - \Delta) + m(x_c - \Delta)}{\Sigma m_i}$$

$$-m_1 \Delta + m_2 - m_2 \Delta + \frac{m_3}{2} - m_3 \Delta = 0$$

$$\Delta = \frac{m_2 + m_3/2}{m + m_1 + m_2 + m_3} = \frac{15 + \frac{10}{2}}{20 + 15 + 10 + 100} = 0.14 \text{ m}$$

$$\Delta > 0$$

Task 4

Research object:

- Pulley
- rope
- Load

Force analysis:

R_x R_y

G_{man} G_{pulley} G_{load}

By intiuition, the man climb the rope then the load on the other side will go up too.

Solution:

$$J = \frac{mr^2}{4}$$

$$v_B = \omega r$$

$$m v_B \cdot r + m(v_B - v) \cdot r + \frac{m}{4} r^2 \omega = 0$$

$$\Rightarrow v_B \cdot r + (v_B - v) + \frac{1}{4} v_B = 0 \Rightarrow \boxed{v_B = \frac{4}{9} v}$$

the load will go up with ~~as~~ velocity $\frac{4}{9}$ a