University Physics A(1)

Worksheet #7

Name (名字): Student number (学号):

New words: Write the Chinese next to these words as you learn them.

elastic collision
inelastic collision
internal energy
translational angular momentum
rotational angular momentum
torque
relative to…

Problems Show all working.

(1) [10.P.21] A car of mass 2300 kg collides with a truck of mass 4300 kg, and just after the collision the car and truck slide along, stucktogether, with no rotation. The car's velocity just before the collision was $\langle 38, 0, 0\rangle$ m/s, and the truck's velocity just beforethe collision was $\langle -16, 0, 27\rangle$ m/s.

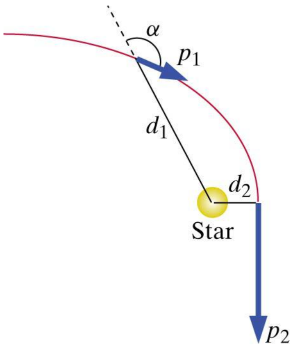
(a) What is the velocity of the stuck-together car and truck just after the collision? Write clearly which fundamental principle you are using, and what objects you choose to be in your system.

(b) In your analysis in part (a), why can you neglect the effect of the force of the road on the car and truck?

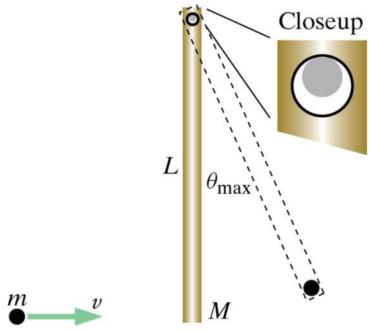
(c) What is the increase in internal energy of the car and truck (thermal energy and deformation)?

(d) Is this collision elastic or inelastic?

(2) [11.P.50] A small rock passes a massive star, following the path shown in red on the diagram. When the rock is a distance 4.5×10^{13}m (indicated as d_1 in the figure below) from the center of the star, the magnitude p_1 of its momentum is 1.35×10^{17} kg · m/s,and the angle is 126°. At a later time, when the rock is a distance $d_2 = 1.3 \times 10^{13}$ m from the center of the star, it isheading in the $-y$ direction. There are no other massive objects nearby. What is the magnitude p_2 of the final momentum?



(3) [11.P.36] A stick of length L and mass M hangs from a low-friction axle (see the figure below). A bullet of mass m traveling at a high speed$v$ strikes near the bottom of the stick and quickly buries itself in the stick.



(a) During the brief impact, is the *linear* momentum of the stick + bullet system constant? Explain why or why not.Include in your explanation a sketch of how the stick shifts on the axle during the impact.

(b) During the brief impact, around what point does the *angular* momentum of the stick + bullet system remainconstant?

(c) Just after the impact, what is the angular speed ω of the stick (with the bullet embedded in it)? (*Hint*: the centerof mass of the stick has a speed $\omega L/2$. The moment of inertia of a uniform rod about its center of mass is$\frac{1}{12}ML^2$.)

(d) Calculate the change in kinetic energy from just before to just after the impact. Where has this energy gone?

第七周作业

(1) (a) 小车、卡车系统中，由动量守恒原理：

$\vec{p}_{初} = \vec{p}_{末}$ 即 $m_{小车}\vec{v}_{小车} + m_{卡车}\vec{v}_{卡车} = (m_{小车} + m_{卡车})\vec{v}_{共}$

代入数据得：$\vec{v}_{共} = (2.82, 0, 17.59)\,m/s$

(b) 道路对系统中小车和卡车支持力与重力抵消，摩擦力因接触时间短也可忽略.

(c) 由能量守恒定律有：

$K_{初} = K_{末} + E_{增}$

即 $E_{增} = K_{末} - K_{初} = \frac{1}{2}(m_{小车} + m_{卡车})|\vec{v}_{共}|^2 - \frac{1}{2}m_{小车}|\vec{v}_{小车}|^2 - \frac{1}{2}m_{卡车}|\vec{v}_{卡车}|^2$

代入数据得：$E_{增} = 2.73 \times 10^6 J$

(d) 非弹性碰撞，因为 $E_{增}$ 不为 0

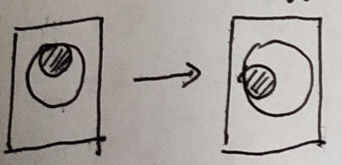
(2) 因为 $\vec{r} \parallel \vec{F}$. 所以 $\vec{r} \times \vec{F} = \vec{0}$

又 $\frac{d\vec{L}_A}{dt} = \vec{\tau}_A = 0$ 则 $\vec{L}_{A,2} - \vec{L}_{A,1} = 0$ 即 $\vec{L}_{A,2} = \vec{L}_{A,1}$

所以 $\vec{r}_{A,2} \times \vec{p}_2 = \vec{r}_{A,1} \times \vec{p}_1$ 在 $-z$ 分量上，$d_2 \cdot p_2 = d_1 \cdot p_1 \cdot \sin\alpha$

所以 $p_2 = \frac{d_1}{d_2} \cdot p_1 \sin\alpha$. 代入数据，解得 $p_2 = 3.8 \times 10^{17} kg \cdot m/s$

(3) (a) 棍+子弹系统动量不是常数. $\Delta\vec{p} = \vec{F} \cdot \Delta t$ 当子弹击中杆时，杆向右移动，击中车轴，轴上有很大力作用在棍上，大多数系统动量被转移到轴上，所以不是常数.



(b) 在木棍中心位置，木棍+子弹系统角动量保持不变.

(c) 由 $\vec{L}_{A,i} = \vec{L}_{A,f}$. 得：$m|\vec{v}_i|L = (I_{棍} + I_{子弹}) \cdot |\vec{\omega}_f|$

$|\vec{\omega}_f| \cdot I_{棍} = \frac{L}{2} \cdot M \cdot \omega \cdot \frac{L}{2} + \frac{1}{2}ML^2\omega = \frac{1}{3}ML^2 \cdot |\vec{\omega}_f|$

$|\vec{\omega}_f| \cdot I_{子弹} = mL^2 \cdot |\vec{\omega}_f|$ 则 $|\vec{\omega}_f| = \frac{m}{\frac{1}{3}M + m} \cdot \frac{|\vec{v}_i|}{L}$

(d) 因为 $K_i = \frac{1}{2}m|\vec{v}_i|^2$. $K_f = \frac{1}{2}(I_{棍} + I_{弹}) \cdot |\vec{\omega}_f|^2 = \frac{1}{2}|\vec{v}_i|^2 \cdot \left(\frac{m^2}{\frac{1}{3}M + m}\right)$

所以 $\Delta K = K_f - K_i = \frac{1}{2}m|\vec{v}_i|^2 \cdot \left(\frac{-M}{M + 3m}\right)$ 这些能量使木棍和子弹温度升高并变形.