作业务必自己抄一遍后再拍照上传，用文档图片上传后果自负。作业尽早提交，老师会尽快批改的，得分也会高一些。如果拖到期末补交普遍得分不高，附上源文档方便查看，如有数据看不清请对照源文档。

University Physics A(1) 2017

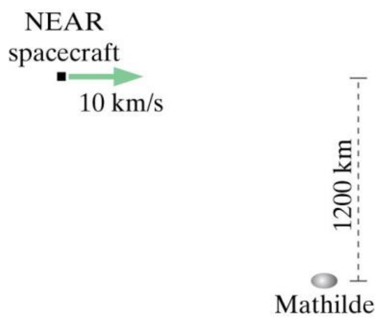
Worksheet #3

Name: Student number:

Problems Show all working.

(1) [3.P.36] In June 1997 the NEAR spacecraft ("Near Earth Asteroid Rendezvous"; see http://near.jhuapl.edu/), on its way to photograph the asteroid (小行星) Eros, passed within 1200 km of asteroid Mathilde at a speed of 10 km/s relative to the asteroid. (See the figure below.) From photos transmitted by the 805 kg spacecraft, Mathilde's size was known to be about 70 km by 50 km by 50 km. The asteroid is made of rock. Rocks on Earth have a density of about 3000 kg/m³ (3 grams/cm³).

(a) Make a rough diagram to show qualitatively (定性的) the effect on the spacecraft of this encounter with Mathilde. Explain your reasoning.



(b) Make a *very rough* estimate (粗略估计) of the change in momentum of the spacecraft that would result from encountering Mathilde. Explain how you made your estimate. [HINT: Assume the force on the spacecraft during the encounter is constant. There is no "correct" answer to this problem – your estimate might be different from mine, and that's okay, as long as your reasoning makes sense.]

(c) Using your result from part (b), make a rough estimate of how far off course the spacecraft would be, one day after the encounter.(一天之后，它离原来的航线大概有多远?)

(d) From actual observations of the location of the spacecraft one day after encountering Mathilde, scientists concludedthat Mathilde is a loose arrangement of rocks, with lots of empty space inside. What was it about the observations that must have led them to this conclusion?

(2) [3.P.63] Object A has mass $m_A = 8\text{kg}$ and initial momentum $\vec{p}_{A,i} =< 20,15,0 > \text{kg}\cdot\text{m/s}$, just before it strikes object B, which has mass $m_B = 11\text{kg}$. Just before the collision object B has initial momentum $\vec{p}_{A,i} =< 5,6,0 > \text{kg}\cdot\text{m/s}$.

(a) Consider a system consisting of both objects A and B. What is the total initial momentum of this system just before the collision?

(b) The forces that A and B exert on each other are very large but last for a very short time. If we choose a time interval from just before to just after the collision, what is the approximate value of the impulse applied to the two-object system due to forces exerted on the system by objects outside the system?

(c) Therefore, what does the Momentum Principle predict that the total final momentum of the system will be just after the collision?

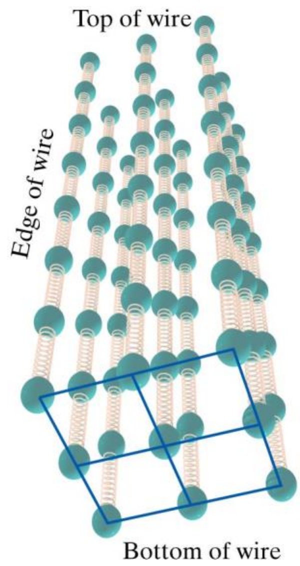
(d) Just after the collision, object A is observed to have momentum $\vec{p}_{A,f} =< 18,5,0 > \text{kg}\cdot\text{m/s}$. What is the momentum of object B just after the collision?

(e) If the objects touch for 0.02 seconds, what is the force exerted by object A on object B?

(3) [4.P.49] One mole (摩尔，atoms)of tungsten (钨) has a mass of 184 grams, and its density is 19.3 grams per cubic centimeter, so the center-to-center distance between atoms is 2.51×10^{-10} m. You have a long thin bar of tungsten, 2.5 m long, with a square cross section (方形横截面), 0.15 cm on a side. You hang the rod vertically and attach a 415 kg mass to the bottom, and you observe that the bar becomes 1.26 cm longer. From these measurements, it is possible to determine the stiffness of one interatomicbond (原子间的化学键)in tungsten.

(a) What is the spring stiffness of the entire wire, considered as a single macroscopic (宏观的), very stiff spring?

(b) How many side-by-side atomic chains (long springs) are there in this wire? [HINT: This is the same as the number of atoms on the bottom surface of the tungsten wire.] Note that the cross-sectional area of one tungsten atoms .



(c) How many interatomic bonds are there in one atomic chain running the length of the wire?

(d) What is the stiffness of a single interatomic (原子间的) "spring"?

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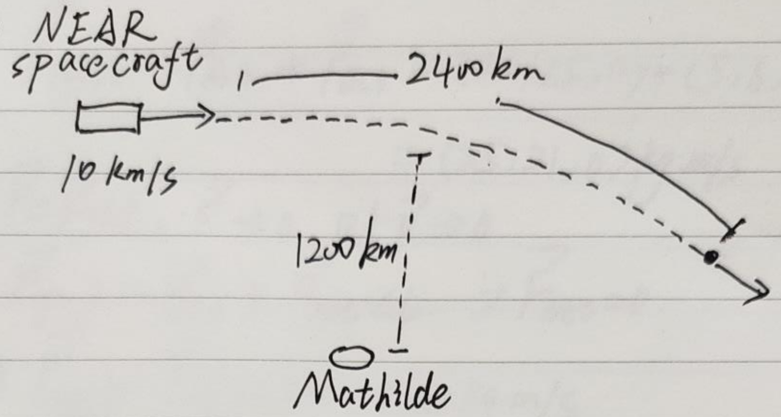
(1) (a)



如果没有 Mathilde，附近的宇宙飞船将以恒定动量在太空中飞行。然而 Mathilde在引力作用下与近地小行星相互作用，当航天器接近并经过小行星时，航天器路径将略微向小行星偏移，这种~~作用~~相互作用对近地天体方向的影响可能比速度影响更大。

(b) $M_{mathilde} \approx 7\times10^4\times5\times10^4\times5\times10^4\times3\times10^3 \approx 5.25\times10^{17}\,kg$

NEAR在 y 轴上动量 $=\Delta P_y \approx F_{NEAR,Mathilde,y}\cdot\Delta t$

$$\approx -\left(G\cdot\frac{M_{NEAR}\cdot M_{mathilde}}{|\vec{F}_{NEAR,Mathilde}|^2}\right)\cdot\left(\frac{d}{|\vec{V}_{NEAR}|}\right)$$

$$\approx -(6.6742\times10^{-11})\cdot\left[\frac{805\times5.25\times10^{17}}{(1.2\times10^6)^2}\right]\cdot\left(\frac{2.4\times10^6}{1\times10^4}\right)$$

$$= -5\,kg\cdot m/s$$

(c) $\Delta y_{NEAR} = \frac{\Delta P_y}{M_{NEAR}}\cdot t = \frac{-5}{805}\times24\times60\times60 = -500m$

(d) 天文学家观察的偏差比预测的要小得多。引力与质量成正比，质量与密度成正比，所以偏差越小，质量越小。NEAR的质量为常数，所以Mathilde质量一定小于预测值.

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(2) (a) $\vec{P}_{sys,i} = \vec{P}_{A,i} + \vec{P}_{B,i} = (20,15,0)+(5,6,0)$

$= (25,21,0)\,kg\cdot m/s$

(b) $\vec{P}=\vec{F}\cdot\Delta t$, $\vec{F}\to 0$, 则 $\vec{P}\to 0$

(c) $\vec{P}_{sys,f} = \vec{P}_{A,i} + \vec{F}_{net}\cdot\Delta t$. 又 $\vec{F}_{net}=0$.

则 $\vec{P}_{sys,f} = \vec{P}_{sys,i} = (25,21,0)\,kg\cdot m/s$

(d) $\vec{P}_{sys,f} = \vec{P}_{A,f} + \vec{P}_{B,f}$, 则 $\vec{P}_{B,f} = \vec{P}_{sys,f} - \vec{P}_{A,f} = (25,21,0)-(18,5,0)$

(e) $\vec{F}_1 = \dfrac{\vec{P}_{B,f}-\vec{P}_{B,i}}{\Delta t} = \dfrac{(7,16,0)-(5,6,0)}{0.02}$ $= (7,16,0)\,kg\cdot m/s$

$= (100,500,0)\,N$

(3) (a) $k \simeq \dfrac{415\times 9.8}{1.26\times10^{-2}} = 3.23\times10^{5}\,N/m$

(b) $N_{chains} \simeq \dfrac{A_{wire}}{A_{atom}} = \dfrac{(0.15\times10^{-2})^2}{(2.51\times10^{-10})^2} = 3.57\times10^{13}$

(c) $N_{bonds\ in\ 1\ chain} \approx \dfrac{L}{d} = \dfrac{2.5}{2.51\times10^{-10}} \simeq 9.96\times10^{9}$

(d) $k_s = \dfrac{3.23\times10^{5}\times 9.96\times10^{9}}{3.57\times10^{13}} \simeq 90\,N/m$