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。

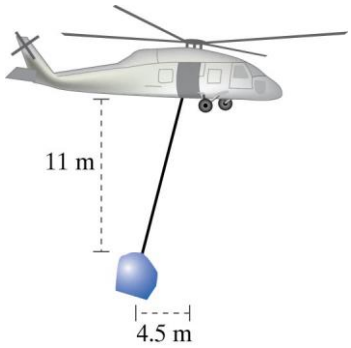
University Physics A(1) 2022

Worksheet #4

Name: Student number:

Problems Show all working.

(1) [5.P.19] A helicopter flies to the right (in the +*x* direction) at a constant speed of 12 m/s, parallel to the surface of the ocean. A 900 kg package is suspended below the helicopter by a cable (缆绳) as shown in the figure below; the package is also traveling to the right in a straight line, at a constant speed of 12 m/s. The pilot is worried about whether the cable, whose breaking strength is 9300 N, is strong enough to support this package.



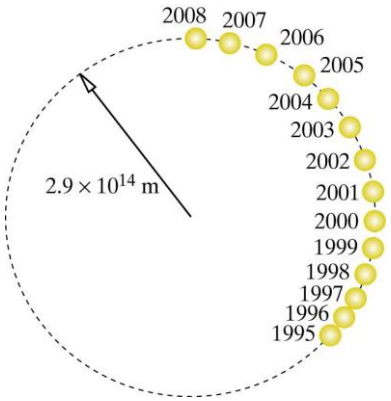
(a) Choose the package as the system. What is the rate of change of the momentum of the system?
(b) List all the objects that are exerting forces on the package.
(c) Draw a careful force diagram ("free-body diagram") showing all the forces acting on the package. Label each force with the name of the object exerting the force.
(d) What is the magnitude of the tension in the cable supporting the package? Carefully show all steps in your work (starting from the Momentum Principle).
(e) Write the force exerted on the package by the cable as a vector.
(f) What is the magnitude of the force exerted by the air on the package? Show all steps in your work
(g) Write the force on the package by the air as a vector.
(h) Is the cable in danger of breaking?

(2) [5.P.48/49] A child of mass 26 kg swings (摇摆) at the end of an elastic cord (弹性绳). At the bottom of the swing, the child's velocity is horizontal, and the speed is 8 m/s. At this instant the cord is 3.10 m long. [You can neglect air resistance.]

First, draw a picture of the situation. Then answer the following questions.

(a) At this instant, what is the parallel component of the rate of change of the child's momentum?
(b) At this instant, what is the perpendicular component of the rate of change of the child's momentum?
(c) At this instant, what is the *net* force acting on the child? (Use the Momentum Principle.)
(d) What is the magnitude of the force that the elastic cord exerts on the child? (It helps to draw a force diagram.)
(e) The relaxed length of the elastic cord is 3.06 m. What is the stiffness of the cord?

(3) Astronomers (天文学家) believe there is a massive black hole (黑洞) at the center of our Milky Way galaxy (银河系). They know this because they have observed the motion of stars orbiting around the center of the galaxy. The figure below shows the motion of one of these stars, called S0-20; the position of S0-20 was measured every year from 1995 until 2008, using the large Keck telescope (凯克望远镜) in Hawaii (夏威夷).



(a) Using the positions and times shown in the figure, what is the approximate speed of this star in m/s? Also express the speed as a fraction of the speed of light.
(b) This is an extraordinarily high speed for a macroscopic (宏观的) object. Is it reasonable to approximate the star's momentum as mv?
(c) Based on these data (数据), estimate the mass of the massive black hole around which this star is orbiting. (Use the Momentum Principle.)
(d) How many of our Suns does this mass represent? (Look at the reference sheet on the class webpage for the mass of the Sun.)

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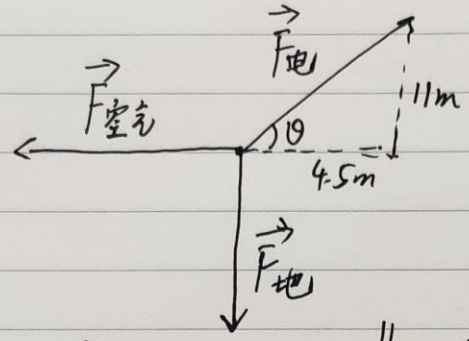
(1) (a) 因为作匀速运动，所以 $\frac{d\vec{p}}{dt}=0$

(b) 物体受地球、空气、电缆的作用力

(c)



(d) 由(c)求 $\theta=\arctan\frac{11}{4.5}=67.8°$

因为合力 $\vec{F}=\frac{d\vec{p}}{dt}=0$ 所以 $\vec{F}_{空}+\vec{F}_{地}+\vec{F}_{电}=\vec{0}$

在x轴上 ~~$F_{电}\cos\theta=F_{空}$~~ $F_{电}\cos\theta=F_{空}$

在y轴上 $F_{电}\sin\theta=F_{地}$ 所以 $F_{电}=\frac{F_{地}}{\sin\theta}=\frac{mg}{\sin\theta}$

$=\frac{900\times9.8}{\sin67.8°}N=9526N$

$F_{空}=9526\times\cos67.8°\approx3600N$

(e) 因为 $\vec{F}_{地}=(0,-mg,0)N=(0,-8820,0)N$

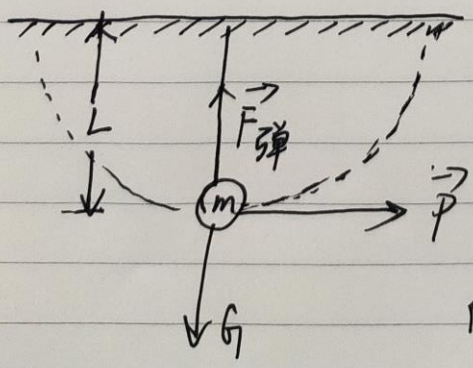
$\vec{F}_{空}=(-3600,0,0)N$.

所以 $\vec{F}_{电}=-(\vec{F}_{地}+\vec{F}_{空})=(3600,8820,0)N$

(f) 由(d)知：$F_{空}=3600N$ (g) $\vec{F}_{空}=(-3600,0,0)N$

(h) 因为 $9526N>9000N$，所以电缆可能会断，有危险.

(2) (a)



$\left|\left(\frac{d\vec{p}}{dt}\right)_x\right|=m\frac{d|\vec{v}|}{dt}=0$

此过程类似匀速圆周运动

在有部水平加速度为0，速度最大

所以水平方向动量为0.

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(2)(b) $\left|\left(\frac{d\vec{p}}{dt}\right)_y\right| = \frac{mv^2}{L} = \frac{26\times 8^2}{3.1} = 536.8\ kg\cdot m/s^2$.

方向竖直向上.

(c) 合力 $\vec{F} = \frac{d\vec{p}}{dt} = (0, 536.8, 0)N$

(d) $\vec{F}_{弹} + \vec{F}_{地} = \vec{F}_{合}$ 即 $|\vec{F}_{弹}| = |\vec{F}_{合} - \vec{F}_{地}| = F_{合} + mg$

$= (536.8 + 26\times 9.8)N = 791.6N$

(e) $\Delta L = 3.10 - 3.06 = 0.04m$

$F_{弹} = k\Delta L$ 即 $k = \frac{F_{弹}}{\Delta L} = \frac{791.6}{0.04} N/m = 1.98\times 10^4 N$

(3) (a) $t = (2008 - 1995)\times 366\times 24\times 60\times 60 = 4.11\times 10^8 s$

$v = \frac{s}{t} = \frac{2\pi R\times \frac{1}{3}}{4.11\times 10^8} m/s = \frac{2\times 3.14\times 2.9\times 10^{14}\times \frac{1}{3}}{4.11\times 10^8} m/s$

$\approx 1.5\times 10^6 m/s = \frac{1.5\times 10^6}{3\times 10^8} c = 5\times 10^{-3} c$

(b) 合理. $\gamma = \frac{1}{\sqrt{1-(5\times 10^{-3})^2}} = 1.000013 \approx 1$.

所以 $\gamma m\vec{v} \approx m\vec{v}$

(c) 因为 $\vec{F}_{合} = \frac{d\vec{p}}{dt}$ 则 $\left|\left(\frac{d\vec{p}}{dt}\right)_\perp\right| = |\vec{F}_{合,\perp}|$

即 $\frac{mv^2}{R} = G\cdot\frac{Mm}{R^2}$ 所以 $M = \frac{v^2R}{G} = \frac{(1.5\times 10^6)^2\times 2.9\times 10^{14}}{6.7\times 10^{-11}} kg$

$= 9.7\times 10^{36} kg$

(d) $\frac{M_{黑洞}}{M_{太阳}} = \frac{9.7\times 10^{36} kg}{2\times 10^{30} kg} = 5\times 10^6$

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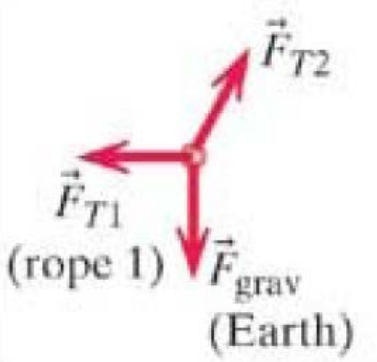
(a) Draw a free-body diagram for the box.



(b) Is $d\vec{p}/dt$ of the box zero or nonzero?

$\frac{d\vec{p}}{dt}$=0，因为盒子是静止的。

(c) What is the y component of the gravitational force acting on the block? (A component can be positive or negative).

$$F_1 = -(40\ \text{kg})\left(9.8\ \frac{\text{N}}{\text{kg}}\right) = -392\text{N}$$

(d) What is the y component of the force on the block due to rope 2?

$$\left|\vec{F}_{T2}\right| \cos 38^\circ = -F_1 = 392\text{N}$$

(e) What is the magnitude of $\vec{F}_2$?

$$\left|\vec{F}_{T2}\right| \approx \frac{392\ \text{N}}{\cos 38^\circ} \approx 497.4\ \text{N}$$

(f) What is the x component of the force on the block due to rope 2?

$$\left|\vec{F}_{T2}\right| \sin 38^\circ \approx 306.2\ \text{N}$$

(g) What is the x component of the force on the block due to rope 1?

$$F_2 = -\left|\vec{F}_{T2}\right| \sin 38^\circ = -306.2\text{N}$$