Physics 101 (S11) **Q1A**

Name: _____ **Section:** _____ **Score:** _____**/20**

1. Sirius is 11 lightyears away from us. How may years does it take a spaceship with a speed 75,000 miles/h to reach Sirius from the earth? 1 lightyear $= 9.5 \times 10^{12}$ km, and 1 mile $= 1.6$ km. If the answer is x years, we have

$$x \text{ year} = \frac{11 \text{ lightyear}}{75,000 \text{ mile/h}}.$$

Use this formula to obtain x. [5]

```
x = (11/75000)(lightyear/mile)(h/year)
  = (11/75000)(9.5 x 10^{12} km/1.6 km)(h/365 x 24 h)
  = (11/75000)(9.5 x 10^{12}/1.6)(1/365 x 24)
  = 9.94 x 10^4
That is, it takes about 0.1 million years or 100 thousand years.
```

2. Solving the following simultaneous equation, find f. [5]:

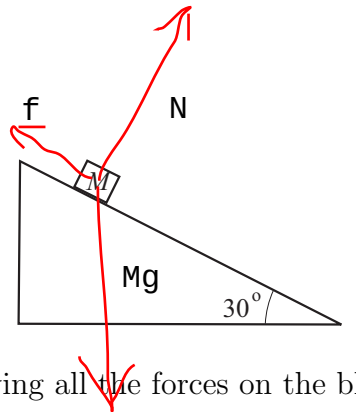
$$360 = f\frac{350}{350+v}, \tag{1}$$

$$430 = f\frac{350}{350-v}. \tag{2}$$

```
They imply (take the reciprocals of the both sides)
     (1/360) = (1 + v/350)/f
     (1/430) = (1 - v/350)/f
Adding them, we get
     1/360 + 1/430 = 2/f = 1/195.9
Thus, f = 392.
```

(**3** on the next page)

3. A block of mass M is at rest on an inclined plane as illustrated below. There is a friction between the block and the inclined plane.



(a) Draw a free-body diagram showing all the forces on the block. [5]

f + N as a vector must be -Mg, that is, the Mg vector flipped.

(b) Can the coefficient μ of static friction be smaller than 0.6? You must give a brief justification of your answer. [5]

The block is at rest, so the friction is enough to keep the block from sliding. Therefore, the actual friction force is

f = N tan(30deg) = 0.577N.

This implies that the coefficient of static friction can be (only slightly larger than) 0.577. Thus, \mu can be less than 0.6.

In short, you must compare the actual and the maximum possible friction forces. If \mu_s allows the max friction still larger than the actual, then the block does not slide.

Name: _____ **Section:** _____ **Score:** _____**/20**

1. A hybrid car can cover 38 km with one ℓ (liter) of gas. How much does it cost to go from Urbana to Chicago that is 120 miles away? Assume that the gas price is \$3/gallon. 1 gallon = 3.785 ℓ. If we write the answer to be x dollars, we have

$$x \text{ dollar} = \frac{120 \text{ mile}}{38 \text{ km}/\ell} \times 3 \text{ dollar/gallon}.$$

Compute x, using this relation.

```
x = (360/38)(mile/km)(liter/gallon)
  = (360/38)(1.6)(1/3.785) = 4.0

That is, we need only $4.
```

2. Solving the following simultaneous equations, find c:

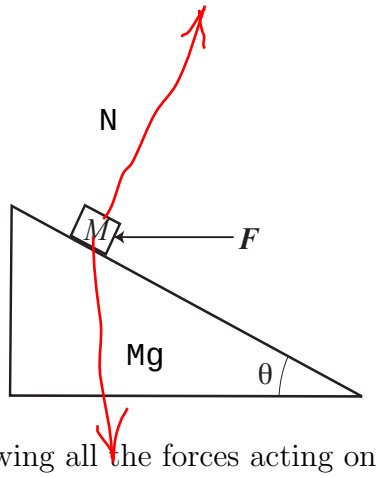
$$480 = f\frac{c}{c+30}, \quad (1)$$

$$520 = f\frac{c}{c-30}. \quad (2)$$

```
They give
     480(c + 30) = fc
     520(c - 30) = fc.
Therefore, 480(c + 30) = 520(c - 30).  (480 + 520)30 = (520 -480)c.
Thus, c = 750.
```

(**3** on the next page)

3. On a frictionless inclined plane making an angle θ with the horizontal direction is a block of mass M, on which a horizontal force $\boldsymbol{F}$ is acting as shown in the figure. The block is stationary.



(a) Draw a free-body diagram, showing all the forces acting on the block. [5]

(b) Write down the magnitude of the force $\boldsymbol{F}$ in terms of M, g and θ. [5]

```
F, Mg and N make an orthogonal triangle, so
     F = Mg tan \theta,
```

Name: _____ **Section:** _____ **Score:** _____**/20**

1. A snail can cover 13 inches in 2 minutes. With this speed how may years does it take the snail to go from Urbana to Chicago that is 120 miles away? Use 1 mile = 1.6 km and 1 inch = 2.54 cm. If we write the answer as x years, then we have

$$x \text{ year} = \frac{120 \text{ mile}}{13 \text{ inch}/2 \text{ min}}.$$

Use this to answer the question. [5]

```
x = (240/13)(mile/inch)(min/year)
  = (240/13)(1.6 km/2.54 cm)(1/365 x 24 x 60)
  = (240/13)(1.6 x 10^3/2.54 x 10^{-2})(1/365 x 24 x 60)
  = 2.2

About 2 years. The numbers given in this problem is realistic.
```

2. Solving the following simultaneous equations, find the ratio v/c: [5]

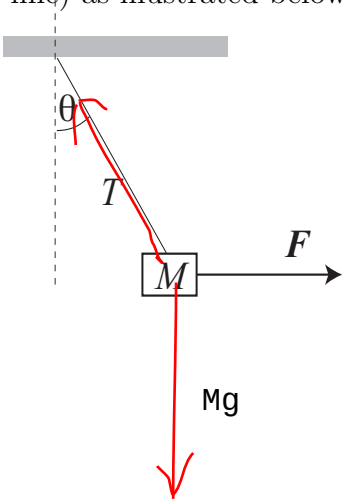
$$480 = f\frac{c}{c+v}, \quad (1)$$

$$520 = f\frac{c}{c-v}. \quad (2)$$

```
Solving both for f, we get
     f = 480(1+v/c)
     f = 520(1-v/c).
Therefore, 480(1 + v/c) = 520(1 - v/c), or v/c = 0.04.
```

(**3** on the next page)

3. A block of mass M hangs from the ceiling with a massless flexible string. A horizontal force $\boldsymbol{F}$ is applied on the block, and the string makes a certain angle θ with the vertical direction (denoted by the dotted line) as illustrated below:



(a) Draw a free-body diagram showing all the forces on the block. [5]

(b) Find the magnitude of the tension T in the string in terms of the magnitude of the force F, M, and g. [5]

```
F is perpendicular to Mg, and F, Mg, and T make an orthogonal
triangle.  Therefore, Pythagorus tells us that
     T = \sqrt{F^2 + (Mg)^2}.
```

Physics 101 (S11) **Q1D**

Name: _____ **Section:** _____ **Score:** _____**/20**

1. A molecular motor can move along a microtubule fiber at a speed of 75 nm/s (1 nm $= 10^{-9}$ m). How many minutes does it take the motor to traverse a cell of diameter 12 micrometers (1 μm $= 10^{-6}$ m)? If we write the answer as x hours, then we have

$$x \text{ min} = \frac{12\,\mu\text{m}}{75 \text{ nm/s}}.$$

Using this relation, obtain x. [5]

```
x = (12/75)(\mum/nm)(s/min)
  = (12/75)(10^{-6}/10^{-9})(1/60)
  = (12/75)(100/6) = 2.67.
```

2. Solving the following simultaneous equations, find f: [5]

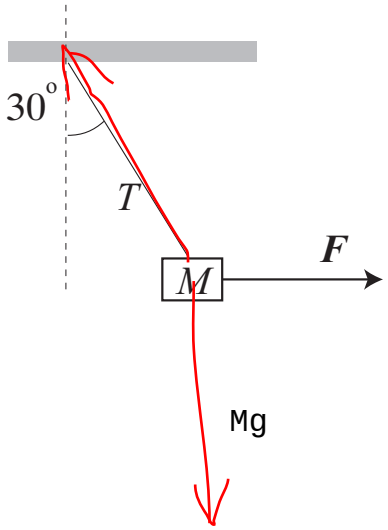
$$480 = f\frac{c+30}{c}, \tag{1}$$

$$430 = f\frac{c-30}{c}. \tag{2}$$

```
Adding the two equations, we obtain
     480 + 430 = 2f.
Therefore, f = 455.
```

(**3** on the next page)

3. A block of mass M hangs from the ceiling with a massless flexible string. When a horizontal force $\boldsymbol{F}$ is applied as illustrated in the following figure, the string makes an angle $30°$ with the vertical direction.



(a) Draw a free-body diagram showing all the forces acting on the block. [5]

(b) Find the magnitude of the tension T in the string in terms of the magnitude of the force F. [5]

T sin(30deg) = F, so T = 2F.