46. A physical quantity f depends on the dimensionful quantities x and y as follows:

$$f = A\,x + B\exp(c\,y)\ .$$

Which of the following *do not* have the same dimensions:

A. f and B

B. c and y^{-1}

C. x and B/A

D. x and A

47. The period of oscillation of a simple pendulum of length L suspended from the roof of a rocket accelerating upwards with a constant acceleration (g) is given by:

A. ∞

B. 0

C. $2\pi\sqrt{\frac{L}{2g}}$

D. $2\pi\sqrt{\frac{L}{g}}$

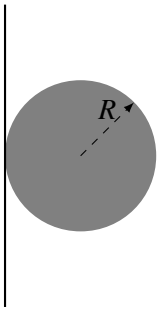
48. The moment of inertia of a uniform solid disc of mass M and radius R about an axis normal to the disk and passing through its center is $\frac{MR^2}{2}$. What is the moment of inertia of the same disc about an axis lying in its plane and tangent to it (as shown in the figure)?

A. $\frac{MR^2}{4}$

B. $\frac{3MR^2}{2}$

C. MR^2

D. $\frac{5MR^2}{4}$



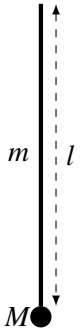
49. A pendulum is made of a rigid rod (mass m, length l) and a small bob of mass M attached at one end (as shown in the figure). The rod is pivoted on the other end. What should be the minimum speed of the bob at its lowest point so that the pendulum completes a full circle?

A. $\sqrt{\frac{12M+6m}{3M+m}gl}$

B. $\sqrt{4gl}$

C. $\sqrt{5gl}$

D. $\sqrt{\frac{15M+6m}{3M+m}gl}$



50. A proton of mass 1 a.m.u. collides with a Carbon-12 nucleus (mass = 12 a.m.u.) at rest. Assuming that the collision is perfectly elastic and that the Newton's laws of motion hold, what fraction of the proton's kinetic energy is transferred to the Carbon nucleus?

A. $\frac{144}{169}$
B. $\frac{48}{169}$
C. $\frac{25}{169}$
D. 1

51. The magnitude of the gravitational force experienced by a small spaceship of mass M inside an inter-galactic dust cloud (assumed to be spherically symmetric but not necessarily uniform) when it at a distance of r from the center of the cloud is found to be

$$F(r) = \alpha r + \frac{\beta}{r}\,.$$

The density of the dust cloud is (G is Newton's gravitational constant)

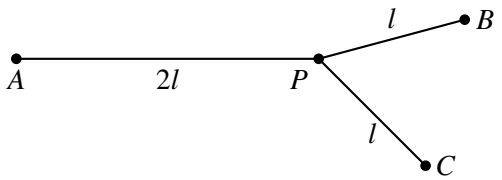
A. $\frac{3\alpha}{4\pi GM}\left(1 - \frac{\beta}{3\alpha r^2}\right)$
B. $\frac{3\alpha}{4\pi GM}\left(1 + \frac{\beta}{3\alpha r^2}\right)$
C. $\frac{3\alpha}{4\pi GM}\left(1 + \frac{\beta}{\alpha r^2}\right)$
D. $\frac{3\alpha}{4\pi GM}$

52. A body cools from 67°C to 37°C. If this takes time t when the surrounding temperature is 27°C, what will be the time taken if the surrounding temperature is 7°C?

A. $2t$
B. $t/3$
C. $t/2$
D. $t/4$

53. Three rods (lengths $2l$, l, l) made of the same material and having the same area of cross-section are joined as shown in figure. The end points A, B and C are maintained at constant temperatures 100°C, 50°C and 0°C, respectively. Assuming that there is no loss of heat from the surface of the rods, find the temperature that the junction P ultimately reaches.

A. 50°C
B. 40°C
C. 30°C
D. 20°C



54. An AC voltage source of frequency 50 Hz and amplitude v_0 is turned on at time $t = 0$. A second voltage source of the same frequency and amplitude is turned on at a later time $t = 5$ ms. For both sources, the voltage is found to increase immediately after being turned on. The instantaneous voltage of the two sources can be represented respectively by $v_1(t)$ and $v_2(t)$, where

A. $v_1(t) = -v_0 \sin(100\pi t)$ and $v_2(t) = +v_0 \cos(100\pi t)$

B. $v_1(t) = +v_0 \sin(100\pi t)$ and $v_2(t) = +v_0 \cos(100\pi t)$

C. $v_1(t) = -v_0 \sin(100\pi t)$ and $v_2(t) = -v_0 \cos(100\pi t)$

D. $v_1(t) = +v_0 \sin(100\pi t)$ and $v_2(t) = -v_0 \cos(100\pi t)$

55. A charged particle (mass m, charge $+q$) is moving in a region of uniform magnetic field $B_0\,\hat{k}$. If at time $t = 0$ the particle is at the origin and has a velocity $\vec{u} = u_x\,\hat{i} + u_z\hat{k}$, what is the position vector $\vec{r}$ of the particle at a later time $\frac{9\pi m}{qB_0}$?

A. $\vec{r} = \frac{2mu_x}{qB_0}\,\hat{j} + \frac{9\pi mu_z}{qB_0}\,\hat{k}$

B. $\vec{r} = -\frac{2mu_x}{qB_0}\,\hat{j} + \frac{9\pi mu_z}{qB_0}\,\hat{k}$

C. $\vec{r} = \frac{9\pi mu_z}{qB_0}\,\hat{k}$

D. $\vec{r} = \frac{2m\sqrt{u_x^2+u_z^2}}{qB_0}\,\hat{j}$

56. A bar magnet of mass m is suspended from the ceiling with a massless string and is set into oscillations. A gold metal plate is brought close to the oscillating pendulum. The oscillations will damp due to induction of eddy currents in the metal. Which one of the following statements is true if the gold plate is replaced by a steel plate having the same physical dimensions. (Of the two, note that gold is a better conductor of electricity.)

A. the amplitude of oscillations will decrease faster

B. the amplitude of oscillations will decrease slower

C. the amplitude of oscillations will increase

D. the amplitude of oscillations will not be affected

57. A charged particle is moving away from a uniformly charged infinite wire along a direction perpendicular to it. Initially, the particle is at a distance L from the wire moving with a velocity u. When it is at a distance $2L$, its velocity is found to be $2u$. What will be the velocity of the particle when it is at a distance $4L$ from the wire ?

A. $\sqrt{6}u$

B. $\sqrt{7}u$

C. $\sqrt{8}u$

D. $\sqrt{9}u$

58. A steel wire of length 1 meter is under a tension of 10 newtons. The speed of the transverse wave excited in this wire is v. The wire is replaced by another steel wire of the same length but half the diameter. What should be the tension in the replaced wire, so that, the speed of the wave stays the same?

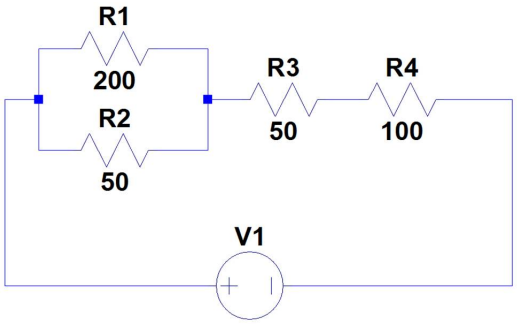
A. 40 N

B. 20 N

C. 5 N

D. 2.5 N

59. Consider the circuit shown in the figure. In which resistor the amount of power dissipated is the largest?



A. R1

B. R2

C. R3

D. R4

60. A biconvex lens with focal length f in air and refractive index of 1.5 is floating on the surface of a deep pond of water (refractive index 1.33). If an object is placed at a height of $2f$ vertically above the lens, then the distance between the lens and the image is

A. f

B. $2f$

C. less than $2f$

D. greater than $2f$
